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FINAL SUMMARY REPORT
SATURN INSTRUMENT COMPARTMENT
GROUND COOLING AIR CONDITIONER 682830-1
PREPARED FOR NASA
G.C. MARSHALL SPACE FLIGHT CENTER
UNDER CONTRACT NAS8-1578)
(NASA

AAC-4209-R July 10, 1962

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3. DESIGN

The air conditioner is similar to a unit recently developed for the U.S. Air Force which is shown in Photograph 39089-4. Pertinent differences are described in Section 6 of this report. These were primarily changes in the recirculation air circuit to match the NASA air flow requirements, explosion proof capability, and 60-cps instead of 400-cps power for heating.

All components were analyzed by AiResearch for explosion-proof capability in accordance with the requirements of Paragraph 5.3.1 of Military Specification MIL-E-5272C and Amendment (1). As a result, the condenser and recirculation fans were modified to meet explosion proof requirements. All other electrical components meet explosion-proof requirements in that they either (a) contain no arcing parts or relays, (b) are hermetically sealed, or (c) are capable of self-contained explosion without propogation in an air-fuel mixture atmosphere. A strip heater was successfully subjected to explosion test as described in Paragraph 8.1. Therefore, the air conditioner is considered capable of meeting MIL-E-5272C (1), Paragraph 5.3.1, explosion proof requirements (air-fuel atmosphere).

4. SYSTEM OPERATION

The schematic arrangement of the system is shown in Figure 2.

The operation of the system is controlled by a manual master selector switch located on the package control panel (see Figure 1). This selector has three positions: (1) OFF, (2) VENT, and (3) AUTO.

The OFF position shuts off all electrical power supply to the package. With the switch in the VENT position, the recirculation air fans are energized but these are the only package components operating. Selection of the AUTO mode brings the remainder of the package components into operation and provides varying degrees of cooling or heating, according to the demands of the temperature control system.

4.1 Cooling Operation

If the temperature control system demands cooling operation, the condenser air fans are energized as soon as AUTO is selected. A time delay relay prevents the Freon compressor from starting until 20 seconds after start of the condenser fans. During cooling operation the Freon compressor, the condenser air fans and the recirculation air fans operate continuously. In the Freon circuit, superheated Freon 114 vapor is drawn into the compressor where mechanical compression raises the energy level of the entering gas to a pressure and a temperature high enough for condensation to take place in the condenser. In the condenser, the hot compressed gas condenses by rejecting heat to the ambient air, which is drawn through the air passages of the condenser by the cooling air fans. The condensed Freon liquid flows from the bottom manifold of the condenser into the receiver, and from there to the liquid port of the Freon control valve, via the subcooler-superheater. This latter unit transfers heat from the liquid Freon leaving the condenser to the gaseous Freon entering the compressor and ensures that any liquid carried over from the evaporator will be evaporated before reaching the compressor.

The Freon control valve modulates the cooling capacity of the evaporator by regulating the mixture ratio of liquid and gaseous Freon entering the evaporator. During maximum cooling demand, the gas port of the valve is closed and only liquid Freon enters the evaporator. As the cooling demand diminishes, the temperature control system modulates the Freon control valve to admit progressively more gaseous Freon and less liquid Freon to the evaporator. The evaporator cooling capacity is thus automatically adjusted to the reduced cooling load.

4.2 Heating Operation

At some intermediate point, the evaporator cooling capacity is reduced to zero and further increases in the amount of gaseous Freon supplied results in the evaporator acting as a heater for the recirculated air. At the fullest extent of its travel, the Freon control valve admits only gaseous Freon to the evaporator. This method of refrigeration system control provides smooth transition from cooling to heat by utilizing the compressor power to provide some heating.

If further heating demands are made, the temperature control system signals are transferred from the Freon control valve to a programmer switch, which is a motor-driven, rotary sequencing device. The initial action of the programmer is to shut off the Freon compressor and the condenser air fans. Thereafter, it provides step control for the electric heater to obtain various levels of heater power input.

If the temperature control system calls for a change from heating to cooling mode, the sequence of events is reversed. The programmer steps down the heater input power until zero input is reached, and then switches on the condenser air fans and the Freon compressor and transfers control to the Freon control valve.

A temperature selector switch on the package control panel allows the operator to select any return air temperature between 60°F and 85°F. A manual damper control allows varying amounts of fresh air to be mixed with the recirculated air if desired.

5. DESCRIPTION OF COMPONENTS

A list of the eleven major package components is presented in Figures 1 and 2. This section of the report gives a description of the major components used in the package.

5.1 Refrigeration System

The refrigeration system consists of the Freon control valve, evaporator, subcooler-superheater, compressor, condenser, condenser air fans, receiver, and condenser pressure controller. Where possible, flexible synthetic rubber hoses were used to connect these components in the refrigeration circuit to simplify assembly and repair to allow tolerance build-up in package fabrication. The system utilizes Freon 114 as a refrigerant, with a one per cent concentration of oil in circulation to provide lubrication for the compressor.

5.1.1 Freon Compressor 570420

The Freon compressor is a compact, lightweight, hermetic type unit, consisting of a two-stage centrifugal compressor which is driven by a squirrel-cage induction type electric motor. The compressor is identical to a current production unit used on the Boeing 707 and Lockheed Electra airplanes with the exception of a change in the compressor diffuser which is a stationary part.

The compressor is extremely simple, utilizing one rotating assembly which is carried on only two ball bearings. This assembly consists of a shaft, motor rotor, and the two compressor impellers. The motor rotor is mounted on the compressor drive shaft. The motor rotor laminations are rigidly bound together with integrally cast aluminum rotor bars to provide a rotor of consistent dynamic balance and rugged construction. The stator is constructed with an aluminum frame cast around the outside of thin-gauge stator laminations to provide maximum rigidity and efficiency. The stator winding insulation system materials are resistant to Freon and oil. The motor leads are connected to ceramic-insulated, hermetic type terminals.

Bearing lubrication and cooling are accomplished by passing a small quantity of liquid Freon containing a small percentage of oil into the motor-compressor shaft. The oil in the form of oil mist lubricates the bearings. As the liquid Freon evaporates and changes to a vapor it absorbs heat from the motor rotor, stator and bearings. The Freon vapor and oil are then delivered to the compressor inlet.

Thermal protection is provided by a thermoswitch in the housing near the lower end of the stator winding. This thermoswitch functions to shut down the motor if excessive temperature is sensed.

The compressor is a hermetic unit with no external dynamic seals. The unit is fitted with a labyrinth type seal at the inlet of each impeller. A floating carbon ring type seal is located between the second-stage impeller and the upper ball bearing. None of these seals are required to be leakproof. A small leakage is permissible since such is entirely internal.

5.1.2 Freon Evaporator 174570

The Freon evaporator is of brazed and welded aluminum construction, utilizing the plate and fin extended surface configuration. The Freon passages are wide, flat, vertical tubes, each containing a single layer of rectangular offset fins. The tubes are reinforced on the leading and trailing edges, to provide resistance to impact and rough handling. The air passages each contain a double row of rectangular offset fins, located between the Freon tubes and set back from the leading and trailing edges for protection during handling.

Freon enters the unit through an integral distribution system in the bottom manifold. Refrigerant liquid is distributed by a perforated tube, and gaseous freon is injected directly into the bottom pan. The refrigerant then travels upward boiling and absorbing heat and is discharged through the top pan.

5.1.3 Freon Condenser 174580

The Freon condenser assembly is an aluminum plate-fin exchanger utilizing the plate fin construction that is used in the 174570 evaporator (the USAF unit). Freon gas from the compressor enters the top manifold of the condenser and condenses while flowing downward through the tubes. Liquid freon is collected in the bottom pan and flows to the receiver by gravity.

5.1.4 Freon Subcooler-Superheater 172210

The subcooler-superheater is a Freon liquid-to-Freon gas heat exchanger located in the compressor suction line. The purpose of the subcooler-superheater is to provide subcooled liquid to the Freon control valve.

It also tends to improve the cycle efficiency. The type of construction of the subcooler-superheater heat transfer surface is identical to the Freon evaporator and condenser.

5.1.5 Evaporator Freon Control Valve 133202

The evaporator Freon control valve is an electrically actuated, dual-flow sliding piston valve. The valve comprises a valve housing with appropriate inlet and discharge ports, a dual piston valve, and an electric motor driven actuator. The valve is a push-pull type which positions the dual piston valve so that when the liquid port is full open, the gas port is full closed. As the load on the evaporator is reduced, the liquid valve moves towards the closed position, and the gas valve simultaneously moves towards its open position to prevent compressor surge.

The valve housing incorporates O-ring type seals to restrict internal leakage from the gaseous side to the liquid Freon side. The valve actuation shaft has a series of three O-ring type seals to prevent external leakage from the valve.

5.1.6 Condenser Air Fan 207642-1

Two of these fans are used in parallel to provide the condenser air flow. Each fan is an axial flow type unit with a 12-inch diameter impeller which is driven by an electric motor. The motor rotor is mounted on a shaft which is supported by two sealed grease-packed ball bearings. The fan is mounted on one end of the rotor shaft and secured in place by a self locking nut. The fan impeller has 15 high performance airfoil blades, that are twisted from hub to tip to provide uniform radial aerodynamic loading across the blades. The motor housing has deswirl vanes to straighten the air flow as it discharges from the fan blades. These vanes are also used to support the electric motor. The outer housing has a bell mouth entrance and a bolt flange at the downstream end for mounting purposes. The motor vent holes include flame suppressors and rubber grommets on the power leads into the motor to meet explosion proof requirements. The motor end cap contains the terminal block for electrical connections and the motor thermal protector.

5.1.7 Freon Receiver 177790-1

The Freon receiver is a cylindrically shaped 340-cubic inch aluminum vessel, the ends of which are hemispheric. Volumetric capacity is 18 lbs of Freon 114 at 70°F. The receiver incorporates a system charge valve, two sight glasses for determining liquid level, and a stainless steel fine mesh strainer at the receiver outlet. Liquid Freon passes from the receiver through a vertical tube to the subcooler-superheater. The strainer is located in this outlet tube and is accessible for removal and cleaning by disconnecting the outlet tubing.

5.1.8 Condenser Shutter Actuator 133256-2

The condenser shutter actuator consists of a Freon-operated actuator and a Freon servo valve coupled with a condenser cooling air shutter assembly. The actuator is a piston type that is operated by compressor discharge Freon gas. The actuator shaft is sealed by a series of three "O" ring type seals. Freon sealing around the piston is accomplished by a Freon resistant rubber diaphragm.

The servo control valve which regulates the Freon pressure to the top of the actuator piston, consists of a small spring-loaded, piston type poppet that is balanced by the Freon pressure differential between the compressor inlet and the compressor discharge. When the differential pressure across the poppet exceeds the control value of the servo the poppet unseats and permits a small amount of Freon gas from the compressor discharge to flow into the lower chamber of the servo. This chamber is connected to the chamber above the piston in the actuator. As the poppet unseats, the pressure increases in the chamber, moving the actuator piston and shutter assembly.

The valve is adjusted to operate the shutters between 68 psi and 60 psi differential between compressor discharge and suction. At 68 psi, the shutters will be wide open and at 60 psi, the shutters will be closed. In this manner, condensing temperatures will always be maintained above 120°F, and normally will be maintained above 130°F. This in turn will always maintain evaporator temperatures above 38°F to minimize freezing problems during cooling operation on mild days.

5.1.9 Miscellaneous Freon System Components

Accessory components of the refrigeration system are as follows:

a. A Mueller Brass B-32513 filter-drier is installed in the compressor motor cooling bypass line. Since this unit is serviced only at overhaul, no valving is provided for its removal.

b. A rupture diaphragm designed to release at 165 psig at 200°F is provided in the Freon circuit to protect the system from overpressure.

c. A wrench operated purge plug is provided at a high point in the system to relieve the system of non-condensible gases if any should be trapped in the system.

d. A sight glass is provided in the liquid line from the receiver to indicate adequate Freon charge in the system.

e. Two J. P. March Co. compound pressure gauges reading 30 in. Hg vacuum to 150 psig are provided to indicate compressor suction and condensing pressures.

f. A Crissair, Inc. 2D1502 check valve is installed in a drain line between the evaporator and receiver. This valve opens during "OFF" cycle, allowing drainage of liquid Freon from the evaporator.

5.2 Recirculation Air System

The recirculation air system consists of the manually adjustable fresh air and recirculation air flow control louvers, the four recirculation air fans, an air filter, and an electric heater. External to the package, the circuit is completed by the customer furnished flexible hoses for the supply and return air. An air flow rate meter is included in the circuit.

5.2.1 Recirculation and Fresh Air Louvers

The air control louvers form an integral part of the air conditioner cabinet. These louvers are simple straight vaned blades which are mechanically linked to a position arm. The two sets of louvers are interconnected so that when the recirculation air louvers are fully open, the fresh air louvers are closed. The louver positioning mechanism is linked to the manual fresh air selector on the control panel.

5.2.2 Recirculation Air Fan 207647-1

Four of these fans are used, in a series-parallel arrangement, to provide the recirculation air flow. Each fan has a 4.75-inch diameter axial flow impeller having 9 high-efficiency aerodynamic airfoils which are twisted from hub to tip in order to provide a constant radial aerodynamic loading. The impeller is made from a one-piece precision aluminum casting. The motor housing and deswirl vanes are also made from a one-piece precision aluminum casting. The motor is a squirrel cage induction type. The motor rotor and fan impeller are mounted on a common shaft which is supported by two sealed grease packed ball bearings. The fan motor vent holes include flame suppressors and the rubber grommets on the power leads into the motors to meet explosion proof requirements.

5.2.3 Air Filter

The recirculating air filter consists of two Farr Company Type A4A4H, 16 x 18 x 1-inch deep aluminum mesh filter sections mounted in an iridited aluminum frame, and located upstream of the evaporator. The filters are held in place by spring clips and are removable from the back of the unit through the lower access panel, and may be cleaned and re-installed as many times as is necessary.

5.2.4 Electric Heater 682489

The electric heater is composed of 15 Chromalox strip-fin type elements which operate on 208-volt, 3-phase, 60 cps electric power. The elements are nickel chromium resistance wires imbedded in a ceramic material and covered with a chrome steel sheath. Fins are pressed on the sheath to provide improved heat transfer to the air stream. The heater is composed of three banks which are arranged in parallel. Bank No. 1 is 4.2 KW heating capacity and Bank Nos. 2 and 3 are 8.35 KW heating capacity each.

5.3 System Electrical Controls

The system electrical controls provide modulation of cooling and heating capacity, switching of motorized equipment and safety devices where required.

5.3.1 Temperature Control 547606

The temperature control is a magnetic amplifier device which receives inputs from the temperature selector and the return air temperature sensor and converts these signals into terms of actuator movement.

The temperature selector and the return air temperature sensor are connected to form two of the arms of a simple resistance bridge. A change in signal from either one of these references causes an unbalance of the bridge and this error is detected, amplified and used to control the output of a hermetically sealed relays. This power output drives either the Freon control valve actuator or the programmer actuator. The power output is in the form of a series of constant voltage amplitude power pulses, the width of the pulse varying from a few milliseconds for small bridge unbalance signals to "full on" for large error signals.

This form of control has proved to be very responsive and yet give good inching characteristics and stable operation.

5.3.2 Temperature Selector 512282

The temperature selector is a wire-wound potentiometer which has an over-all resistance change equal to the resistance change of the return air temperature sensor between the temperature limits of 60°F and 85°F. The return air temperature is selected by altering the resistance of the selector and therefore changing the bridge balance point.

5.3.3 Return Air Temperature Sensor 47518

The duct sensor is constructed of a thermistor element which contains a small piece of semiconductor material. This material has a predictable negative temperature coefficient of resistivity and the resistance of the thermistor is therefore a definite reproducible function of its immediate surrounding temperature. The sensor is located in the return air duct of the air conditioner.

5.3.4 Air Temperature Indicator 162B11

Included on the control panel is a Lewis Engineering Company temperature indicator gage, Part No. 162B11, to show the dry bulb temperature of the conditioned air leaving the air conditioner. The indicator is connected to a wire-wound temperature bulb thermometer type 56B4A. The indicator gage readout has a range of 0 to 150°F with 5°F graduations.

5.3.5 Motor Protector Relay 515206

The motor protector relay contains two separate circuits providing two separate functions. One circuit is used to detect ground currents or faults and to trip a latching type relay, which in turn interrupts the control power to the compressor motor contactor. Any ground current in excess of 15 amperes between the motor protector relay and the motor will trip the relay. The purpose of this circuit is to remove the motor from the line following a possible electrical short or ground, in order to limit possible damage to the compressor.

The second circuit is used to detect possible excessive winding temperatures, and to trip a second latching type relay, which in turn interrupts the control power to the compressor motor contactor. This circuit operates in conjunction with a thermal switch located in the compressor motor case to protect against motor overloads. At a predetermined combination of motor current and case temperature, the thermal switch will open, thereby actuating the latching relay. This relay interrupts the control current to the motor contactor. After the motor case cools to about 170°F, the thermal switch will automatically reset.

Both latching relays may be reset by pressing a momentary contact switch located on the control panel.

5.3.6 Current Transformer 547604

The current transformer is a device used to limit the maximum current drawn by the compressor. It accomplishes this by producing a signal proportional to the current drawn by the compressor above 80 amperes. Above this compressor current level, the signal produced by the current transformer is substracted electrically in the magnetic amplifier from that of the temperature sensor. This causes the control temperature point to increase above that selected. This in turn causes the expansion valve to close down to provide less cooling which will result in the compressor drawing less current.

5.3.7 Time Delay Relay RF20

The time delay relay is a hermetically sealed, adjustable thermal delay device manufactured by G. V. Controls, Inc. A 28-volt current flowing through a resistance element trips a normally open bimetal switch after a predictable time delay. Timing from approximately 5 to 30 seconds is provided by screwdriver adjustment.

5.3.8 Programmer D24460

This unit is a hermetically sealed, motor operated, rotary programmer which contains 8 cam operated switches. These switches start and stop the refrigeration system and step control the electric heater. The motor is a 115-volt, 400-cps single-phase unit with a nominal timing for a full cycle of 50 seconds. The programmer is manufactured by the A. W. Haydon Co.

5.3.9 Miscellaneous Electrical Controls

a. Mechanical Products, Inc., MP Series circuit breakers are provided to protect the wiring to each 3-phase load, and to serve as disconnect devices for servicing.

b. Hartman Electric power relays provide control of each 3-phase load. They are actuated by a 28-volt DC solenoid, and are the totally enclosed type with dust proof cases.

c. A rectifier system consisting of a transformer and four diodes arranged in a full-wave bridge supplies up to 5 amps of 28-volt DC power for control purposes.

d. A 115-volt, 400-cycle synchronous timer is provided on the control panel. This unit gives a digital elapsed time count to 10,000 hours of compressor operation and is hermetically sealed.

e. A Weston Model 833, 0-300 amp ammeter is provided to indicate total air conditioning current in one phase of the air conditioning system. This unit will give a good indication of refrigeration system operation.

f. A phase sequence sensing relay is provided which automatically prevents the unit from operating if power supply phasing is wrong.

5.4 Air Conditioner Cabinet and Miscellaneous Items

The air conditioning system with its controls is housed in an aluminum structure designed to provide weather protection and support for the system (Figure 1). Particular attention has been paid to service and overhaul accessibility. The basic enclosure consists of a welded frame made up of extruded sections. The system components are supported from this frame, and aluminum sheet is spot welded or riveted to provide ducting and skin.

Weather protection is provided by a hinged lid on the top of the unit which exposes the condenser fan discharges and exhaust relief. Another door is provided on the condenser air inlet. Weather protection for the fresh air inlet is provided by the variable shutters. The 10-in. hose connections are provided with shipping covers. Removable screens are included in all openings.

Handling of the air conditioner is facilitated by combination grab handles and lifting points located at each corner of the cabinet. A skid base (with fork lift provisions) and a towing eye are included for ground handling.

Thermal and acoustical insulation is provided by 3/4-in. thick Urethane insulation lining in the evaporator compartment and in other critical areas. The entire cabinet was iridited and prime coated. The exterior and interior were given one coat of white paint as specified.

The control panel, located on the side of the unit, consists of an enclosure inside of which all contactors, relays, etc., are mounted for ease of servicing and protection, and a panel on which operating and indicating devices are located. An additional instrument panel is included to accommodate compressor Freon suction pressure, Freon head pressure and the air flow indicator. System wiring is distributed from the control enclosure in cables to the various devices in the air conditioner. Two receptacles with weather caps are located on the cabinet exterior for 208*-volt, 3-phase, 400-cps and 208*-volt, 60-cps power inputs, respectively.

6. CONTRACT EXPENDITURES

Air Conditioner 682830-1 is similar to a previously developed unit for the U. S. Air Force. Listed below are the changes which were made to

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*Line (or phase-to-phase) voltages.

the USAF air conditioner to meet the NASA problem statement, which resulted in extensive drawing changes.

a. Four high pressure rise Recirculation Fans 207647-1, in a series-parallel arrangement, replaced one fan to meet NASA air flow requirements. The 207647-1 fan was derived from a unit in production. The production article was modified to include flame suppressors in the motor breather vents and rubber grommets at the power leads to meet explosion-proof requirements.

b. Condenser Fan 207642-1 is identical to the fan utilized in the USAF unit except for changes to meet explosion-proof requirements. The original configuration fan was modified to include flame suppressors at the motor breather vents and rubber grommets on the power leads. Also, the thermal protector was changed to provide increased motor protection.

c. The latest production configuration Shutter Control Actuator 133256-2 was incorporated into the unit. This part included all the latest product improvement changes.

d. The electrical circuit was modified to operate the heaters on 208-volt, 60-cps power. This included a separate 60-cps power input receptacle mounted on the cabinet and a separate power relay.

e. The cabinet was strengthened by changing the panels from 0.032-in. to 0.050-in. thick aluminum sheet. This was to accomodate the high pressure rise fans (Item a) since the cabinet is essentially a pressure vessel. Angle brace stiffeners were added to the evaporator compartment to mount the four evaporator fans. Angle brace stiffeners were added to the skid assembly along with provisions for fork lift handling. The recirculation inlet and outlet hose connections were changed to accomodate 10-in. hose instead of 24-in. hose. At the recirculation air outlet a plenum reduction was used to accomplish the hose area reduction. These changes resulted in increasing unit overall weight from the 537 lb originally estimated.

f. The control box assembly was modified, the Freon suction and head pressure gages were relocated, and an air outlet temperature gage was included. An additional panel was included to accommodate the Freon suction and head pressure gages along with the air flow indicator. This necessitated a window for gage readout in the rear access panel.

The above changes are summarized to show reasons for over-expenditure of contract funds. These changes involved modification to a larger number of drawings of the originally proposed unit than was anticipated. Also, the time and labor in locating, procuring, and expediting parts was as extensive for one unit as it would have been for a significantly larger order. In ordering small detail parts, the minimum quantity that could be ordered exceeded the number required for one unit. As a result, the surplus parts not used, listed in Table I, also added to unit price. (These parts are being stored in the AiResearch Bond Room pending NASA instructions.) Although the air conditioner was similar to one recently developed for the USAF, the actual personnel learning curve started over. This was due to the fact that personnel who had worked on the USAF unit were not available to work on the 682830-1 air conditioner. Had more units followed the one ordered the cost would have been considerably less.

7. FABRICATION

7.1 The fabrication of the service test unit was divided into three major work areas: component fabrication, cabinet fabrication and unit assembly. The major components were generally modifications of units in production for other programs at AiResearch, or utilized tooling in common with units in production.

7.1.1 The cabinet was fabricated by AiResearch Aviation Service Division since other bidders were substantially higher. Tooling from the USAF-developed unit was used to also minimize cost and expedite fabrication. Generally, separate frame members and panels were cut from raw stock and final trimming was accomplished at final assembly. The frame members were welded and panels riveted to the frame. Photograph 38443-5 shows the similar USAF unit cabinet structure at initial phase of fabrication.

8. TESTING

8.1 <u>Explosion Test of Strip Heater</u> - An SEF 190 strip heater, manufactured by E. C. Weigand Company, identical to that installed in Air Conditioner 682380-1, was subjected to an explosion test to demonstrate compliance with Paragraph 4 of Design Specification for Saturn Instrument Compartment Ground Cooling System which is Enclosure I of Request for Quotation No. TP85-153. Test procedure and results are summarized in Rototest Laboratories Report 3124, included in Appendix II. The heater completed the test without damage and did not propagate an explosion of the air-fuel mixture within the test chamber.

8.2 <u>Performance Test</u> - The air conditioner was operated at the conditions listed in Table 4 to demonstrate performance in compliance with the design specification. The test setup is depicted in Figure 3. For this test, the air conditioner was placed in an enclosure. A portion of the condenser outlet air was deflected into the enclosure to attain the condenser inlet air temperature. Also at this time, the heaters were operated at full heating and 20 kw input power was recorded. This results in a heating capacity of approximately 68,300 Btu per hr. The functional and calibration tests required over 20 hours of unit operational time, and approximately two weeks of testing in the laboratory.

8.2.1 During preliminary system checkout, Condenser Shutter Actuator 133256-2 malfunctioned three times due to dirt accumulations within the valve Freon circuit. A filter was installed in the Freon supply line to the actuator to preclude reoccurrence.

8.3 Recirculation Air Circuit Calibration - The setup is depicted in Figure 3. The fresh air dampers and pressure relief vent were closed and sealed with tape to minimize air leakage so that all air passing through the fans was measured. The unit was operated in the ventilation mode (Freon compressor off; vent fans on) and the recirculation air flow was varied from 98 to 68 lb per min by manually positioning the recirculating air dampers. Test results are tabulated in Table 2 and also depicted in Curve 2.

8.4 Air Flow Indicator Calibration - The unit was operated in ventilation mode and the fresh air shutters were closed (normal leakage) to simulate normal installation. The recirculation air flow was varied from 930 to 1260 cfm by manually positioning the recirculating air damper. At 25 cfm increments, the air flow indicator (inclined manometer) reading was recorded. Curve 2 presents the results of this calibration test. Inlet air flow was measured by a standard ASME orifice measuring section. Finalized test results are presented in Table 3 and Curve 3. The air flows tabulated in Table 3 and the abscissa of Curve 3 were obtained by utilizing Curve 2. This was done to present flow indicator reading versus supply air flow since normal leakage at an undetermined rate through the fresh air dampers occurred during the test.

9. COMPONENT PERFORMANCE

Curves 1 through 18 present the performance of each major component of the air conditioner. Noted on each curve are station points to relate the specific curve to its location in the system as noted in Figure 2.

10. QUALIFICATION TESTS

The functional and calibration tests included herein describe the extent of the tests conducted upon the subject unit. The shock, vibration, and explosion tests were omitted by Modification No. I of Supplemental Agreement to Contract NAS8-1578, dated 10-16-61, and therefore, were not conducted.

11. RECOMMENDATIONS

The following changes to the air conditioner to attain increased performance are submitted:

a. Eliminate the fresh air feature. This was included in the original USAF unit design since this unit was intended for use as a cooling unit for personnel shelter. The feature results in loss of performance due to leakage through the shutters and is considered not necessary for an electronic equipment compartment.

b. The capacity can be improved if the external pressure rise requirements are reduced. This is probably not possible for the intended application. However, the air conditioner may be used in a different application in which the external pressure requirements are reduced. If the input power to the recirculation fans is reduced, more evaporator capacity is available due to useful space cooling. This could be accomplished in this unit by substitution of fans or by removing two of the fans that are in series. This would result in a fan configuration of two parallel fans rather than the present configuration of two fans in parallel and two in series.

c. The capacity could also be increased when the outside ambient is less than 100°F by adjusting the condenser pressure control to a lower value. This would allow a reduction in the evaporator discharge Freon pressure and the evaporator discharge air temperature.

APPENDIX I

Data Tables, Curves, Figures
and Photographs

UNUSED MISCELLANEOUS PARTS

(Due to minimum order purchase requirements)

Part No.	Description		Quantity
172622-3	Weld (bracket) Assembly		2
460-015-40	Gask-O-Seal		3
460-015-12	Gask-O-Seal		4
460-015-20	Gask-O-Seal		5
FR 668-6	Clamp		4
802-2380	Clamp		4
M1000-2-15	Latch		6
2D-1502	Check Valve	Same box	1
H4100-S.063	Latch	Same box	1
172299	Screen	Same box	1
3-4	O Ring		23
3-6	O Ring		22
MS25043-32C	Cap (W/Chain)		5
B-138F	Contactor (Hartman)		3
B-133	Contactor (Hartman)		1
AN 3057-20	Connector		4
AN 3066-20	Nut		4
AN 3064-20	Bushing		4
AN 3057-16	Connector		1
MS 3101R16S-1S	Connector		1
MS 3103-20-33S(C)	Connector		1
MS 3102A14S-2S(C)	Connector		1
2600-10	Stud		12
C-33	Clip		7
AN93132-56	Grommet		4
MS35489-26	Grommet		9
MS25043-32C	Tees		3
MS21911-4D	Tees		5

Table 1

UNUSED MISCELLANEOUS PARTS (Continued)

Part No.	Description	Quantity
MS21902-6D	Coupling	6
MS21903-4D	Bulkhead Fitting	5
AN910-3	Couplings	2
MS21908-6D	Elbows	5
	STRATOFLEX FITTINGS	
255114-12-0380		1
255111-12-0254		1
255110-12-0200		1
255100-20-0455		1
255102-6-0224		1
255106-6-0350		1
255101-6-0100		1
255107-6-0460		2
255104-6-0320		2
255114-12-0440		2
255109-6-0204		1
255106-6-0300		1

NOTE: All parts listed are being held in AiResearch CPFF Bond Room pending disposition instructions from NASA.

Symbol	Parameter	1	2	3	4	5	6	7	8	9
P_{AMB}	Unit Ambient Air Pressure, In. Hg Abs	29.93 ———								29.93
P_{1S}	Recirc. Inlet Air Static Pressure*, In. H_2O G	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3
T_{1D}	DB Temperature, Deg F	65	65.5	65	65	63.5	63	62.5	62	62
W_R	Weight Flow, lb per min	97.8	95.0	91.4	88.5	85.0	82.0	77.5	73.4	68.0
P_{2S}	Conditioned Air Outlet Static* Pressure, In. H_2O G	2.7	7.8	12.8	17.4	21.6	25.8	30.0	34.3	38.0
T_{2D}	DB Temperature, Deg F	81	83	83	85	86	86	87	88	90
ΔP_{12}	Recirc. Inlet to Cond. Air Outlet Static Pressure Differential, In. H_2O	3.0	8.1	13.1	17.3	21.9	26.1	30.3	34.6	38.3
Q_T	Unit Total Cooling Capacity, Btu per hour		Unit in "ventilating" mode (Freon compressor OFF, Recirculation fans ON)							
V_I	Unit Input Line Voltage, Volts a-c	200	201	201	201	201	201	201	201	201
I_P	Unit Input Phase Current, Amps A	24.0	24.0	25.2	25.8	26.4	26.8	27.2	27.4	27.0
	B	←			NOT RECORDED					→
	C	←			NOT RECORDED					→
KW	Unit Input Power, KW	7.35	7.7	8.0	8.2	8.4	8.5	8.6	8.7	8.6
PF	Power Factor (Calculated)	0.88	0.90	0.91	0.93	0.91	0.91	0.91	0.91	0.91
θ	Duration of Test, Hours	←			2.3					→

* Refer to Figure 3 for Static tap locations

CALCULATED BY	Strassel	6-62	CALIBRATION OF RECIRCULATION AIR CIRCUIT AIR CONDITIONER 682830-1, SERIAL 71-01 (AIR DAMPERS SEALED WITH TAPE)	AAC-4209-R TABLE 2
TRACED BY				
CHECKED BY				
APPROVED BY			AIRESEARCH MANUFACTURING CO. LOS ANGELES, — CALIFORNIA	
UNIT NO.				

P_{AMB}	Unit Ambient Pressure, in. Hg Abs	30.00												30.00
P_{1S}	Recirc. Inlet Air Static Pressure,* in. H_2O G	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3
T_{1D}	DB Temperature, Deg F	72	73	72	71	70.5	70	69.5	69.5	68.5	68.5	68.5	68.5	68
N_R	Recirculation Air Weight Flow, lb per min (obtained from Curve 2)	69.8	71.9	74.2	76.1	78.2	79.9	81.5	83.3	85.7	87.1	90.1	92.3	94.0
P_{2S}	Conditioned Air Outlet Static Pressure,* in H_2O G	38.0	36.0	34.0	32.1	30.0	28.0	26.1	24.0	21.0	18.1	15.1	12.1	9.6
	DB Temperature, Deg F	81	88	93	94	94	98	92.5	92	91	90	89	88	88
	Recirc. Inlet to Cond. Air Outlet Static Pressure Differential, in. H_2O	38.3	36.3	34.3	32.4	30.3	28.3	26.4	24.3	21.3	18.4	154	12.4	9.9
Q	Unit Total Cooling Capacity, Btu per hour	Unit inoperative except for recirculation fans												
V_L	Unit Input Line Voltage, volts ac	202	202	202	202	202	202	202	202	202	202	202	202	202
I_P	Unit Input Phase Current, Amperes A	27.0	27.2	27.2	27.2	27.2	27.2	27.0	27.0	26.5	26.2	25.6	25.2	24.8
	B	NOT RECORDED												
	C	NOT RECORDED												
KW	Unit Input Power, KW	8.3	8.4	8.4	8.4	8.4	8.4	8.3	8.3	8.2	8.0	7.9	7.8	7.6
P_F	Power Factor (Calculated)	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.89	0.88	0.88	0.89	0.88
θ	Duration of Test, Minutes	44												
	Air Flow Indicator Reading, in. H_2O	0.24	0.26	0.29	0.31	0.33	0.35	0.37	0.39	0.42	0.44	0.47	0.49	0.52

*Refer to Figure 3 for static tap locations

PREPARED Strassel 5-62	CALIBRATION OF AIR FLOW INDICATOR AIR CONDITIONER 682380-1, SERIAL 71-01, (AIR DAMPERS UNSEALED)	AAC-4209-R Table 3
WRITTEN	AIRESEARCH MANUFACTURING CO. LOS ANGELES, CALIFORNIA	
APPROVED		

P_{AMB}	Unit Ambient Air Pressure, In. Hg Abs	30.00	30.00	29.93	29.93	29.92
P_{1S}	Recirc. In Air Static Pressure, In. H_2O Gage*	-0.1	-0.05	-0.6	-0.7	-0.1
T_{1D}	DB Temperature, Deg F	79	88	102.5	118	91.5
T_{1W}	WB Temperature, Deg F	59.8	62.4	67	70.6	62
W_R	Weight Flow, Lb Per Min***	84	83	79	74.5	84
P_{2S}	Conditioned Air Out Static Pressure, In. H_2O Gage	25.2	24.9	28.4	27.2	27.3
T_{2D}	DB Temperature, Deg F	42.5	43.5	52	57.5	47
T_{2W}	WB Temperature, Deg F	40.5	42.0	48	49.2	44
T_{CI}	Condenser Air In Temperature, Deg F	105	102	100	106	110
Q_T	Total Unit Cooling Capacity, BTU Per Hour	54,900	58,300	51,000	64,400	52,800
Q_E	Evaporator Cooling Capacity, BTU Per Hour**	83,900	86,900	84,900	90,000	81,300
P_{FS}	Compressor In Freon Pressure,psig	0	1.0	2.0	2.0	2.0
P_{FH}	Compressor Out Freon Pressure, psig	60.0	60.0	65.0	66.0	66.0
T_{CASE}	Compressor Case Temperature, Deg F	101	100	97	98	97
V_L	Unit Input Line Voltage, Volts A	199	199	197	198	198
	B	199	199	196	197	197
	C	199	199	196	197	197
I_P	Unit Input Phase Current, Amps A	129	129	124	120	131
	B	129	129	125	120	132
	C	129	129	125	118	132
KW	Unit Input Power, KW	38.2	38.2	35.2	36.0	38.8
θ	Duration of Test, minutes	15	25	15	20	15
	Air Flow Indicator Reading, In. H_2O	0.48	0.49	← NOT RECORDED →		
	Outlet Air Temperature Indicator Reading, Deg F	42	44	← NOT RECORDED →		

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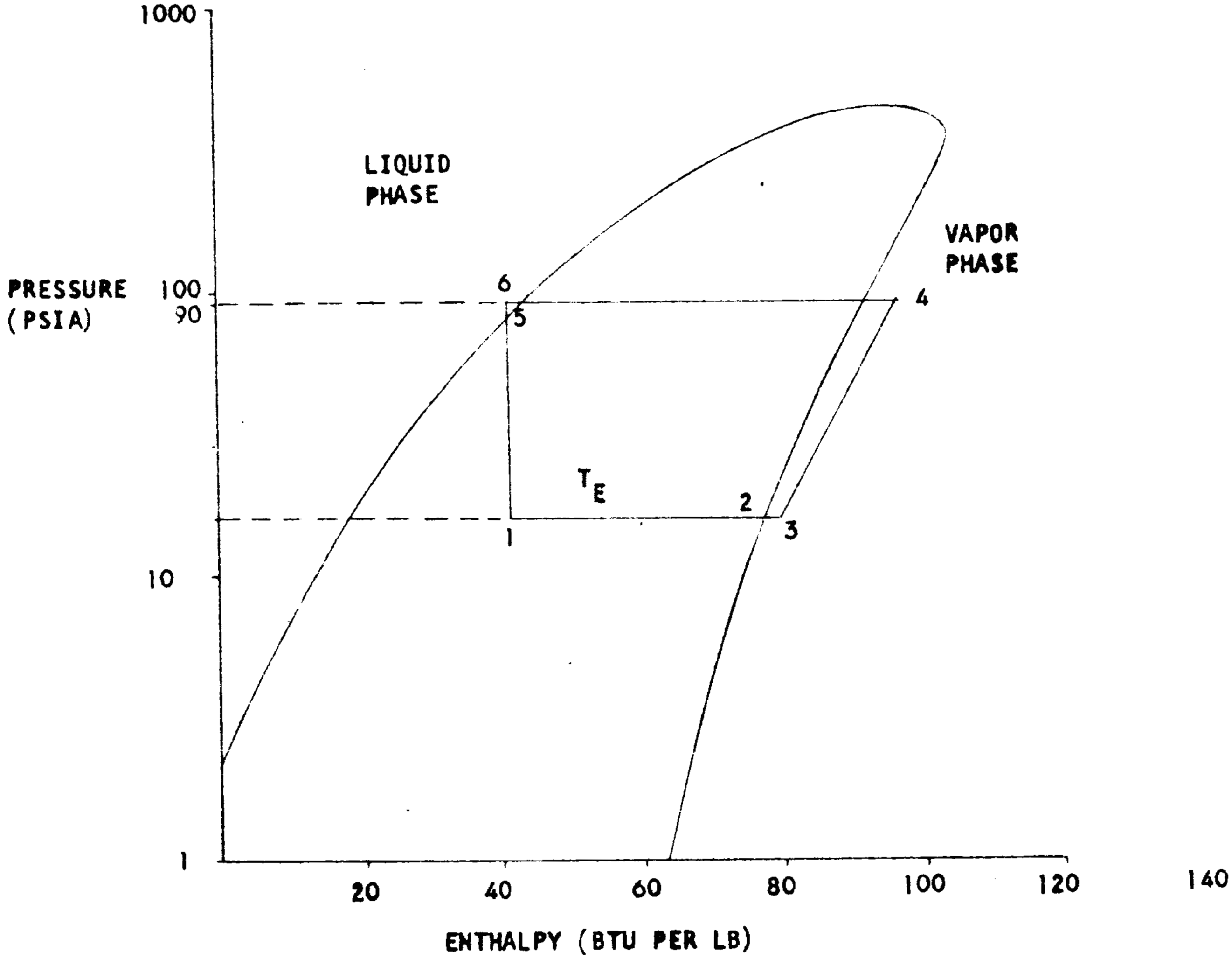
*Refer to Figure 3 for static tap locations

**Calculated on basis of previously measured 8.6 KW for vent fan input power and 100 per cent heat distributed to evap. in air (5.75 BTU per lb)

***Fresh air dampers closed and sealed off with tape for minimum leakage

PREPARED	Strassel	3-62	SUMMARY OF PERFORMANCE TESTS AIR CONDITIONER 682830-1, SERIAL 71-D1	AAC-4209-R TABLE 4
WRITTEN			AIRESEARCH MANUFACTURING CO. LOS ANGELES, CALIFORNIA	
APPROVED				



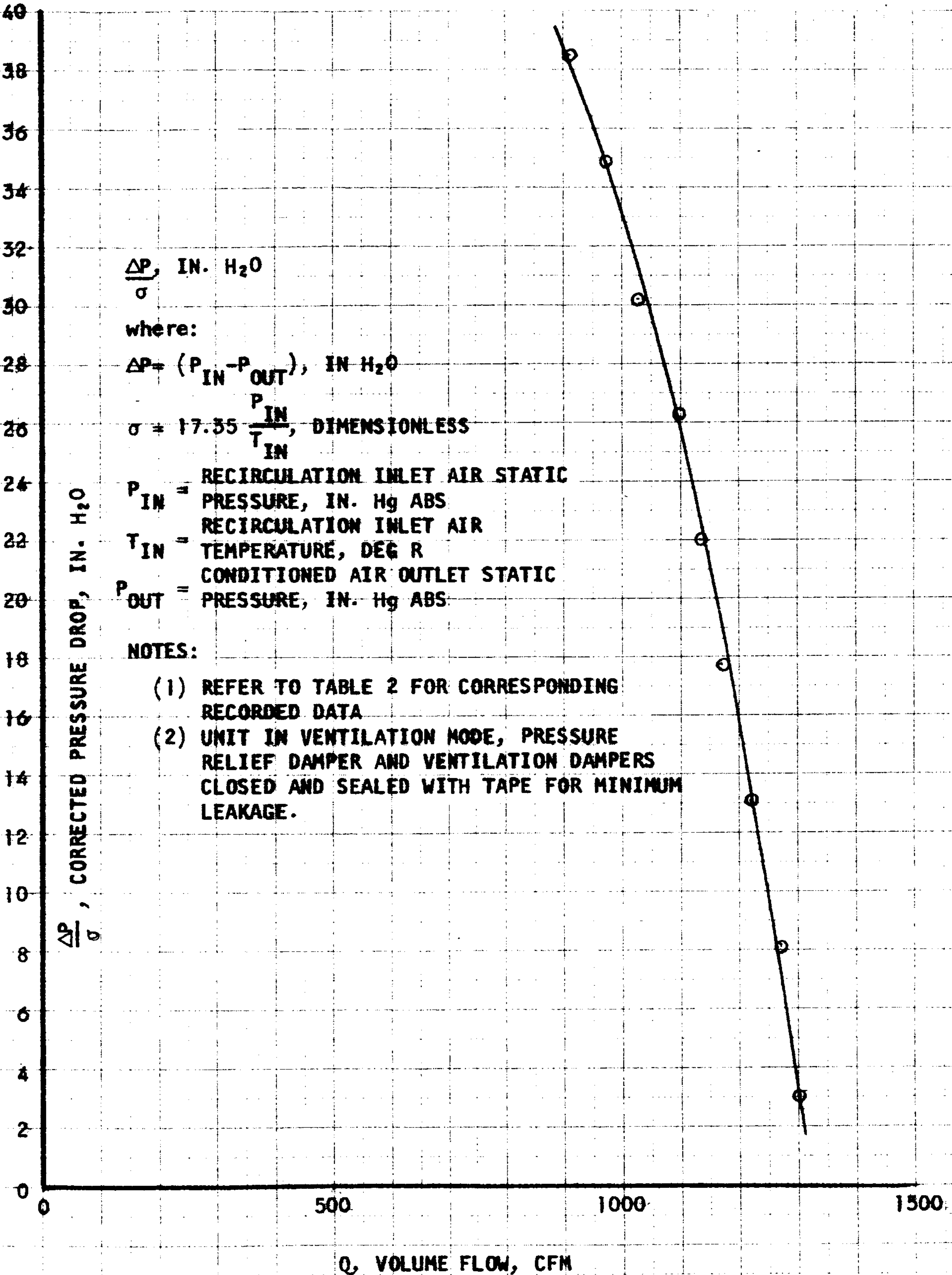
Station Point	Position in System
1	Evaporator Inlet
2	Evaporator Discharge
3	Compressor Inlet
4	Compressor Discharge
5	Condenser Discharge
6	Subcooler Discharge

Condensing Temperature, T_C = 148F

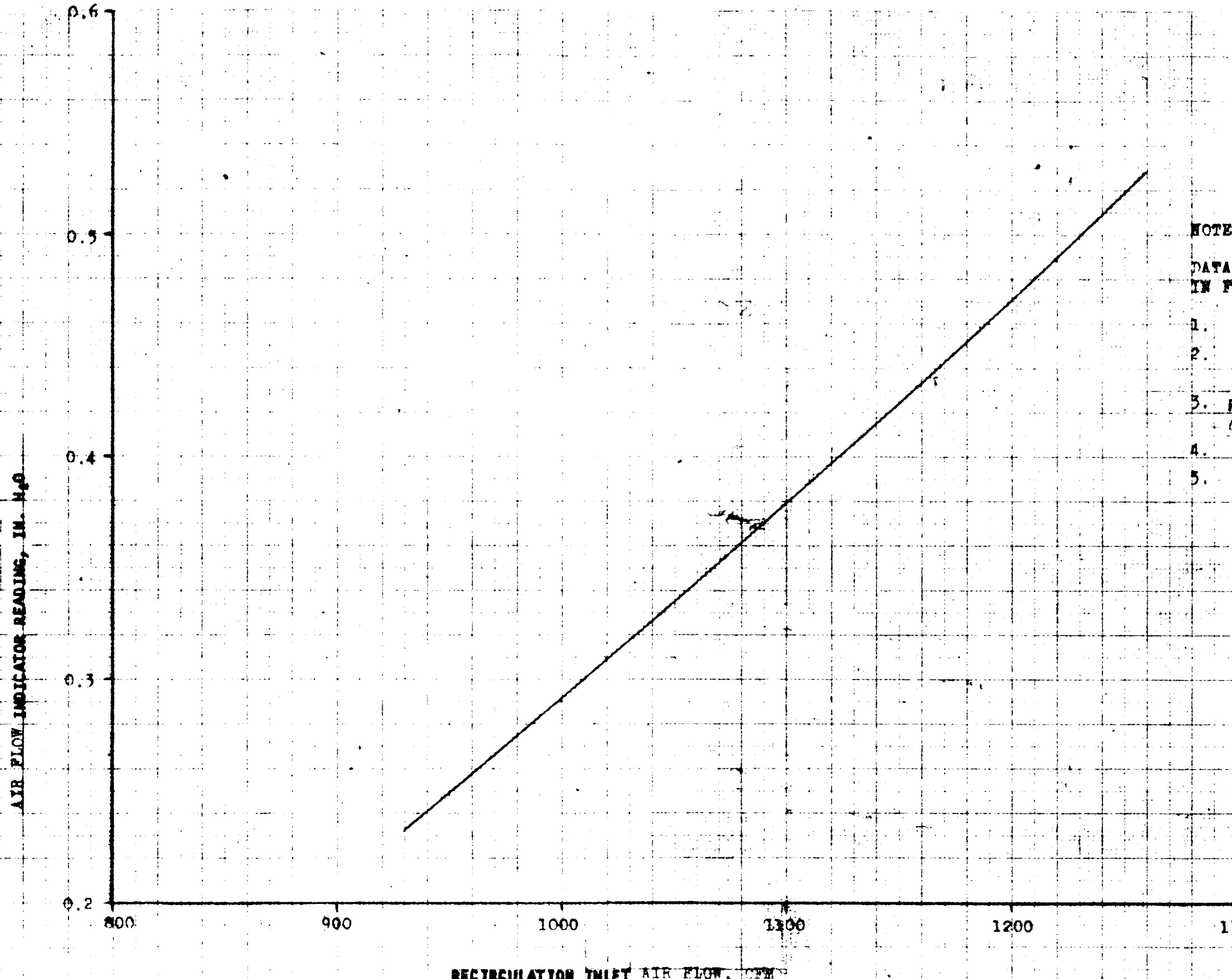
Evaporating Temperature, T_E = 40.1F

PREPARED	LOWE	1-61	THERMODYNAMIC CYCLE FOR FREON 114 REFRIGERANT (125°F DAY CONDITION)	AAC-4209-R CURVE 1
WRITTEN				
APPROVED			AIRESEARCH MANUFACTURING CO. LOS ANGELES, CALIFORNIA	

FORM 783 REV



CALCULATED BY	Susag	2-62	CALIBRATION OF RECIRCULATION AIR CIRCUIT AIR CONDITIONER 682830-1, SERIAL 71-01	AAC-4209-R CURVE 2
TRACED BY	strassel	6-62		
CHECKED BY	Bescoby	7-62		
APPROVED BY	Bescoby	7-62	AIRESEARCH MANUFACTURING CO.	
UNIT NO	682830-1		LOS ANGELES CALIFORNIA	



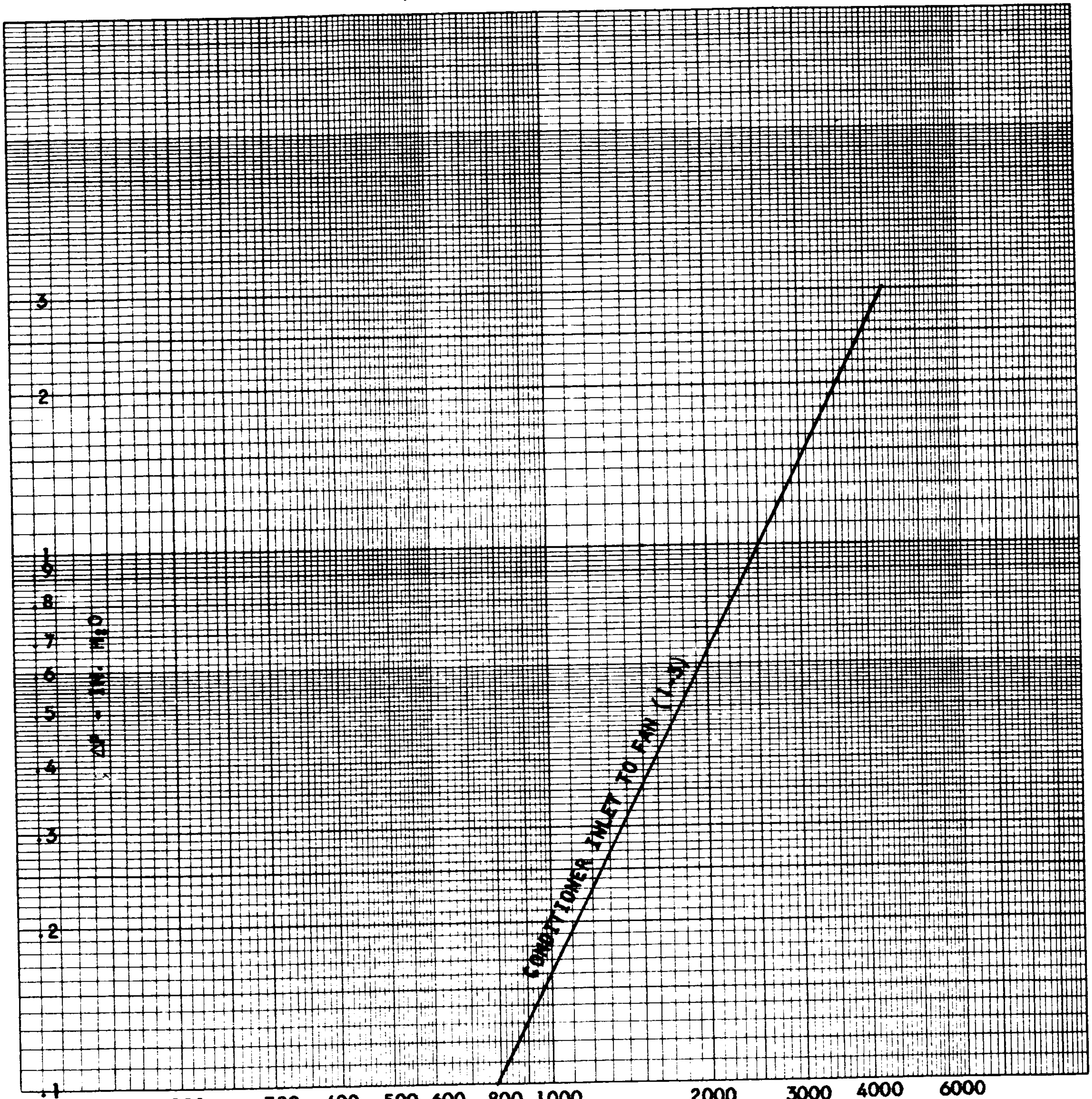
NOTE:

DATA SHOWN HEREIN OBTAINED IN FOLLOWING MANNER:

1. OUTSIDE AIR DAMPER CLOSED
2. PRESSURE IN RETURN AIR PLENUM 0.3 IN. Hg VACUUM
3. RECIRCULATION INLET AIR TEMPERATURE = 70°F
4. PRESSURE RELIEF DAMPER CLOSED
5. UNIT SELECTOR SET FOR "VENTILATION"

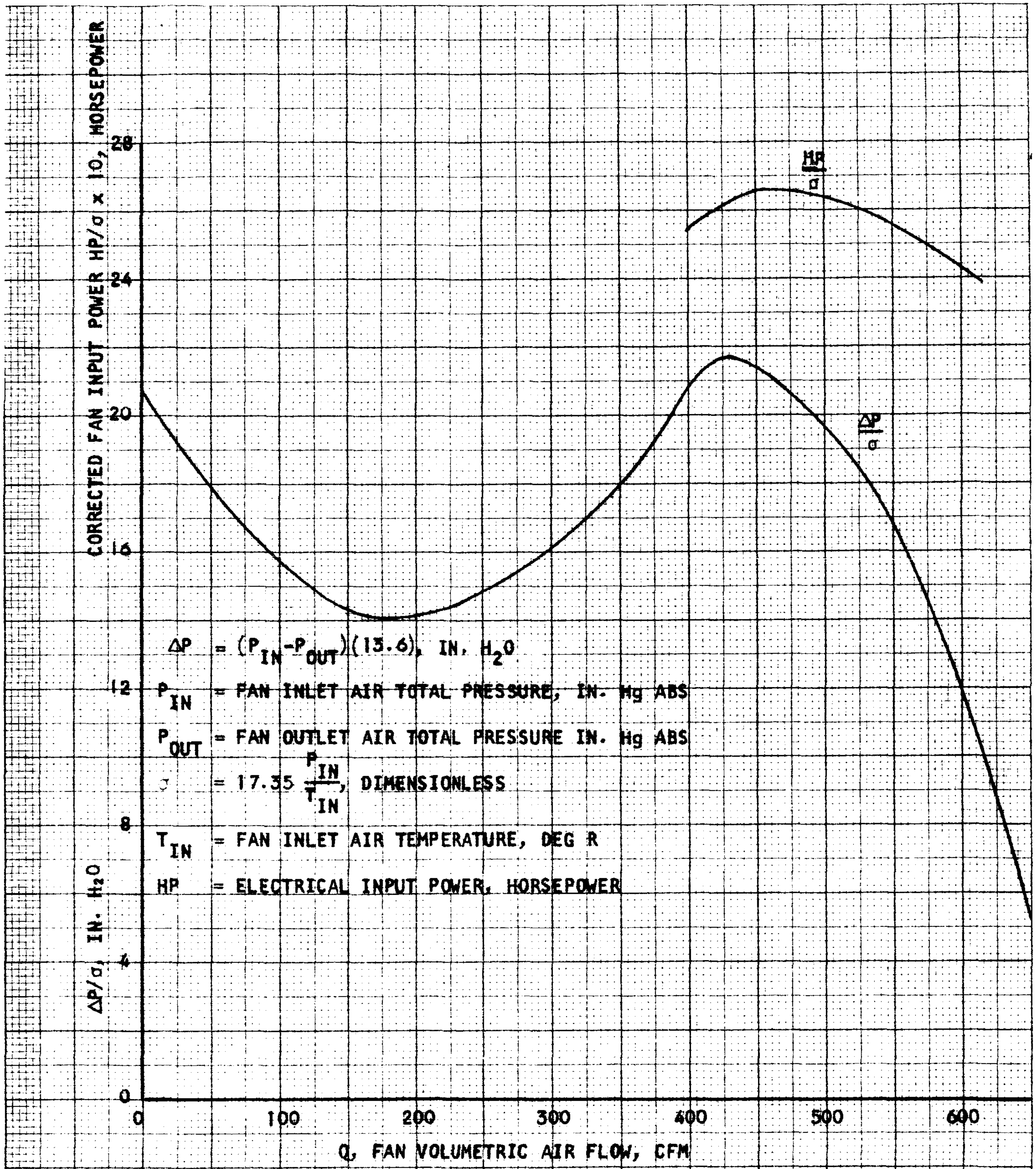
CALCULATED BY	JLS	11-61	AIR FLOW GAGE CALIBRATION NASA SATURN AIR CONDITIONER	AAC-4209-R CURVE 3
TRACED BY	JLS	11-61		
CHECKED BY	GHD	11-61		
APPROVED BY	PAB	11-61	AIRESEARCH MANUFACTURING CO. LOS ANGELES — CALIFORNIA	
UNIT NO.	682830-1			

(STATION POINTS 1-3)



CALCULATED BY			ESTIMATED CIRCULATION AIR PRESSURE LOSSES	AAC-4209-R CURVE 4
TRACED BY	STRASSEL	3-62		
CHECKED BY				
APPROVED BY			AIRESEARCH MANUFACTURING CO. LOS ANGELES, - CALIFORNIA	
UNIT NO.				

(STATION POINTS 3-4)



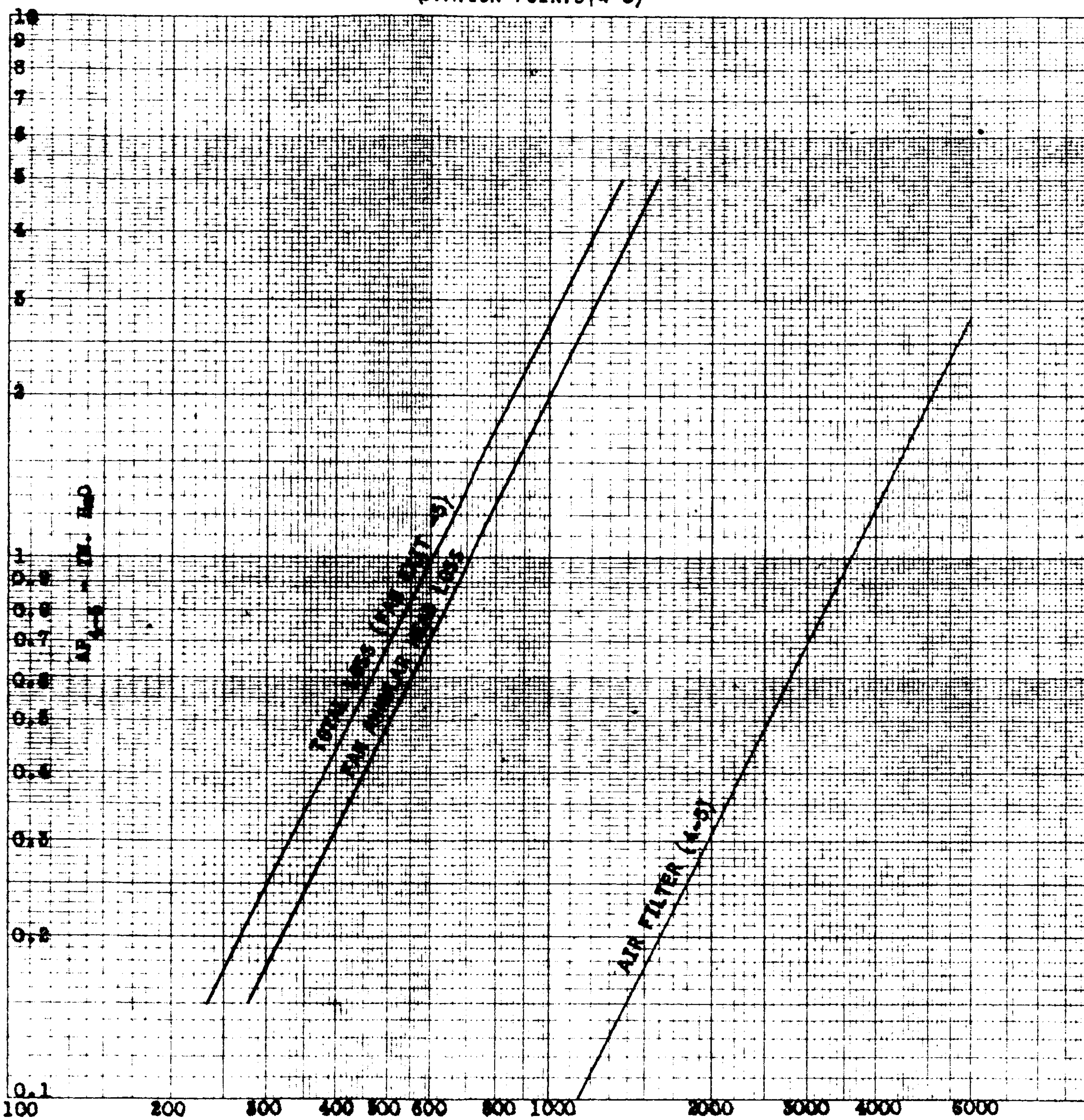
CALCULATED BY	Vilona	3-61
TRACED BY	Strasse	3-62
CHECKED BY		
APPROVED BY		
UNIT NO.		

PERFORMANCE OF
VENTILATION FAN 207647-1

AIRESEARCH MANUFACTURING CO.
LOS ANGELES CALIFORNIA

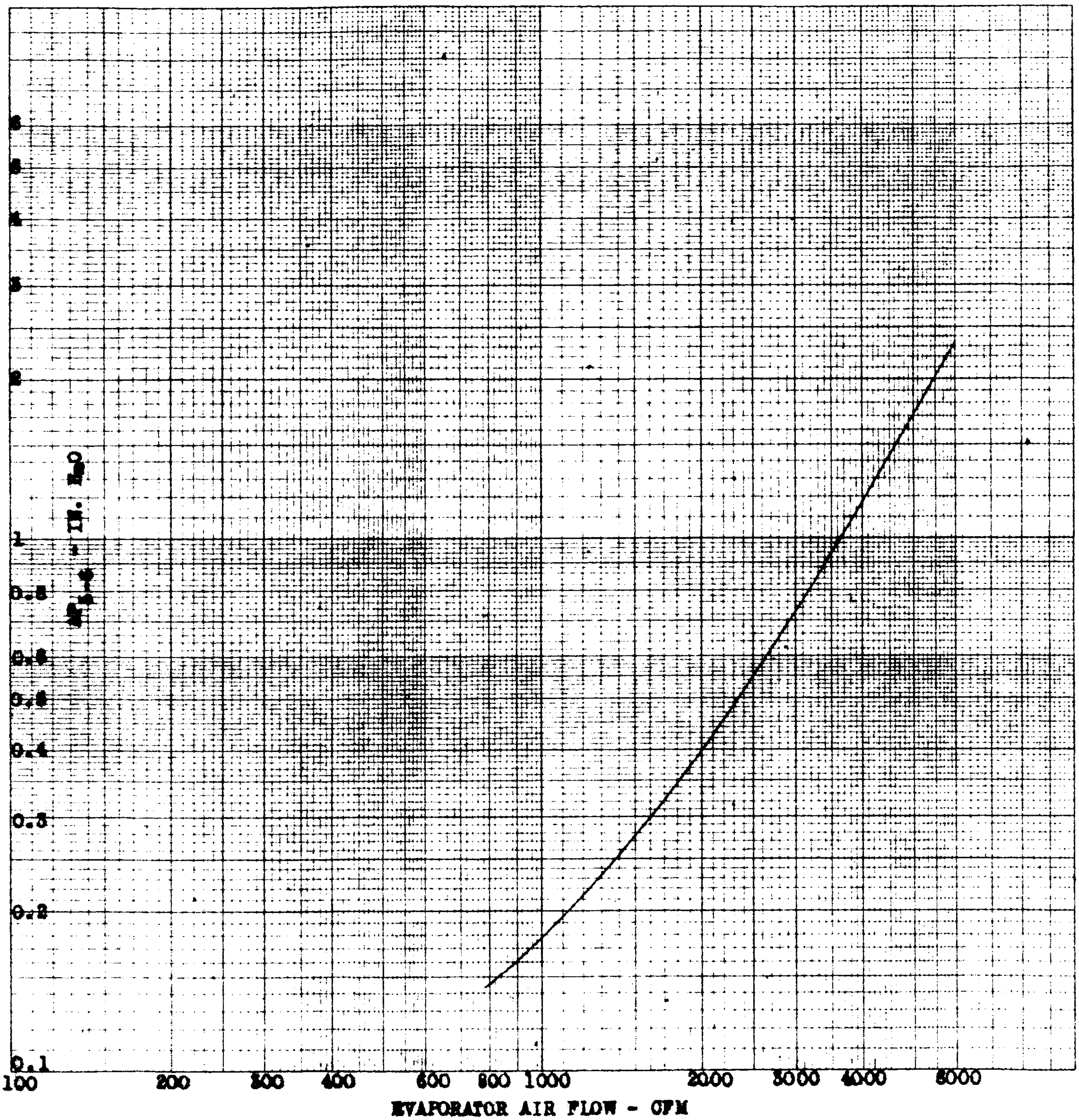
AAC-4209-R
CURVE 5

STATION POINTS (4-5)



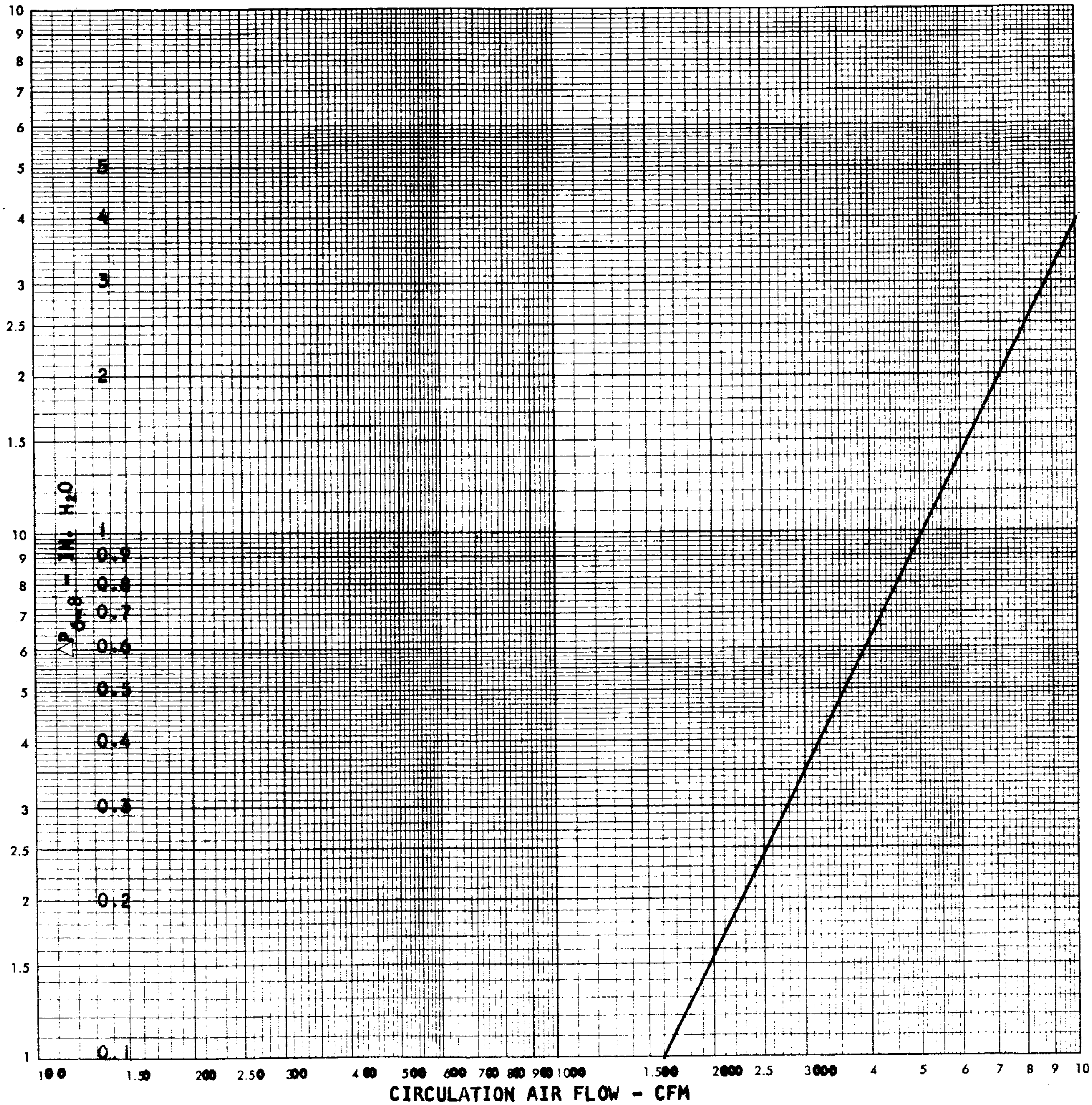
CALCULATED BY	Strassel	3-62	ESTIMATED CIRCULATION AIR PRESSURE LOSSES CIRCULATION FAN TO EVAPORATOR	AAC-4209 CURVE 6
TRACED BY				
CHECKED BY				
APPROVED BY			AIRESEARCH MANUFACTURING CO. LOS ANGELES, — CALIFORNIA	
UNIT NO.				

(STATION POINTS 5-6)



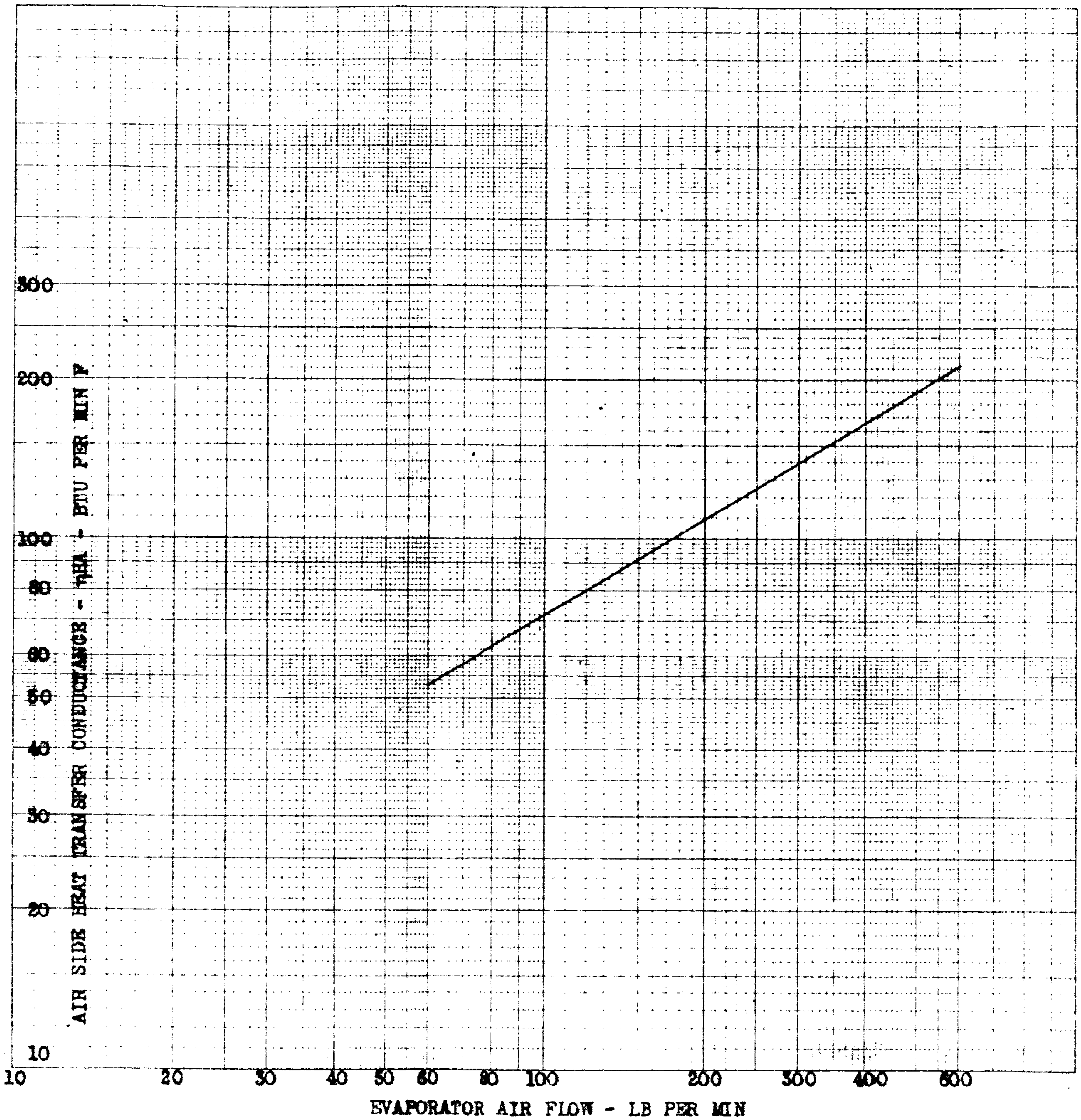
CALCULATED BY			ESTIMATED PERFORMANCE FREON 114 EVAPORATOR 174570	AAC-4209-R CURVE 7
TRACED BY	STRASSEL	3-62		
CHECKED BY				
APPROVED BY			AIRESEARCH MANUFACTURING CO. LOS ANGELES, — CALIFORNIA	
UNIT NO.				

(STATION POINTS 6-8)



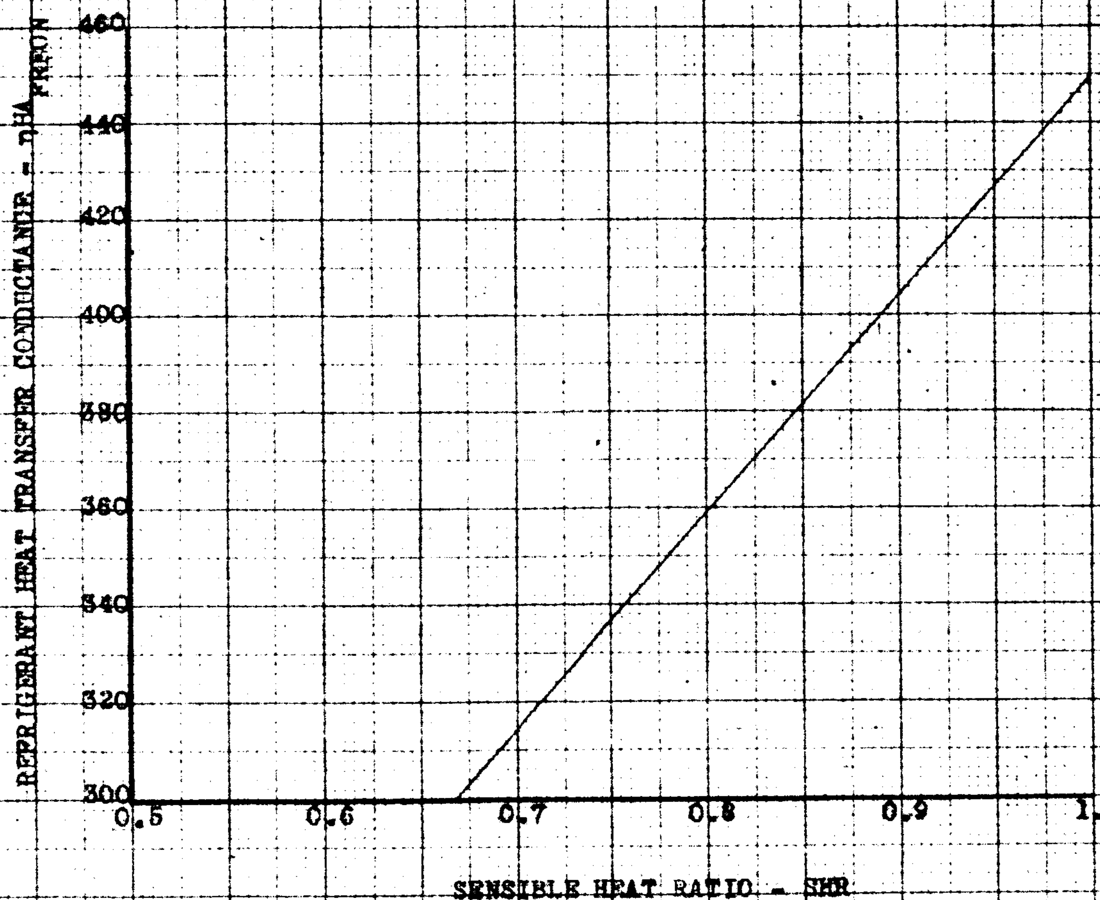
CALCULATED BY			ESTIMATED PRESSURE LOSS EVAPORATOR DISCHARGE TO SUPPLY HOSE	AAC-4209-R CURVE 8
TRACED BY	STRASSEL	3-62		
CHECKED BY				
APPROVED BY			AIRESEARCH MANUFACTURING CO. LOS ANGELES, — CALIFORNIA	
UNIT NO.				

(STATION POINTS 5-6)

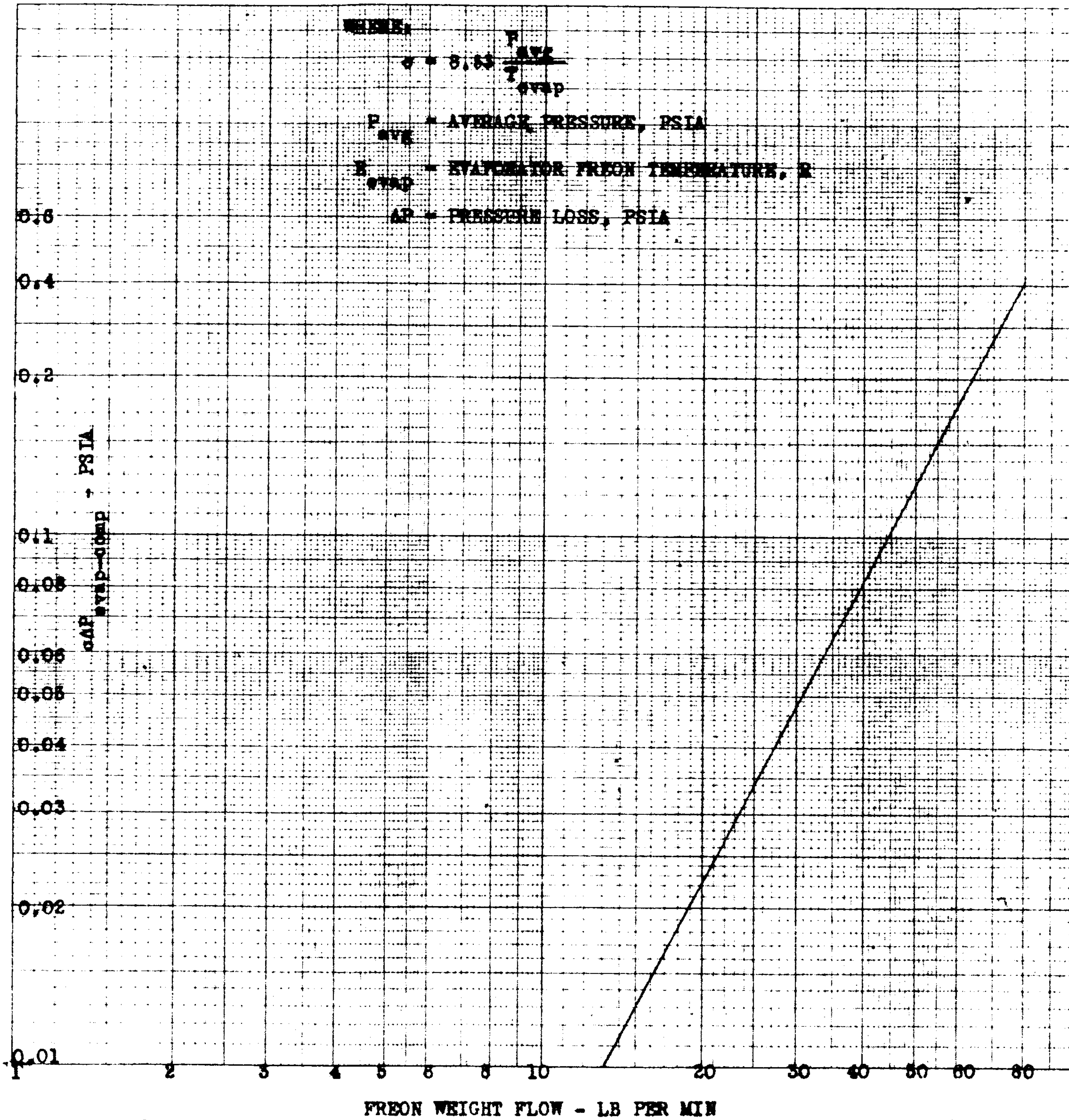


CALCULATED BY		ESTIMATED PERFORMANCE FREON 114 EVAPORATOR 174570	AAC-4209-R CURVE 9
TRACED BY	STRASSEL 3-62		
CHECKED BY			
APPROVED BY		AIRESEARCH MANUFACTURING CO. LOS ANGELES, — CALIFORNIA	
UNIT NO.			

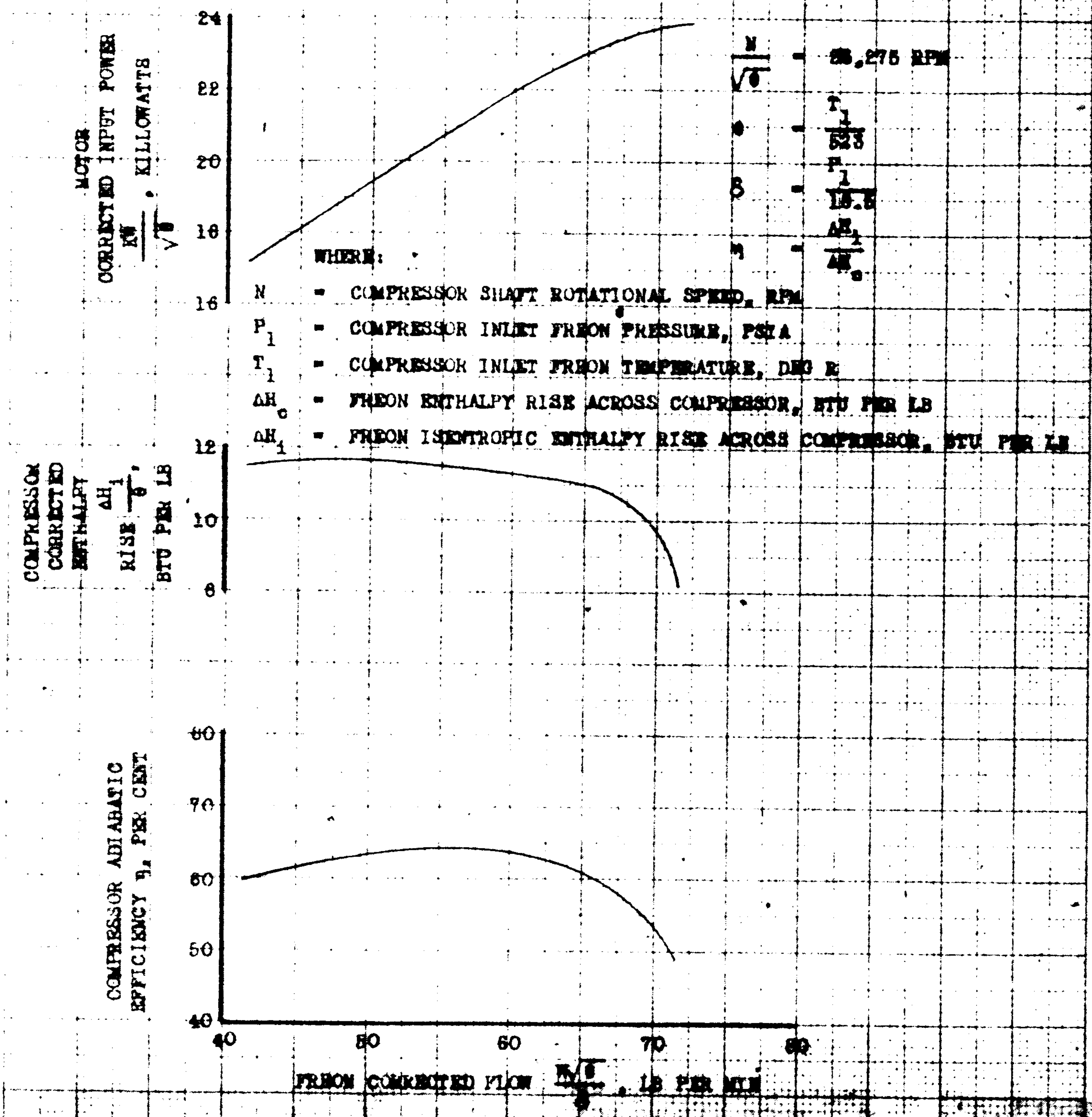
(STATION POINTS 5-6)



CALCULATED BY			ESTIMATED PERFORMANCE FREON 114 EVAPORATOR 174570	AAC-4209-R CURVE 10
TRACED BY	STRASSEL	3-62		
CHECKED BY				
APPROVED BY			AIRESEARCH MANUFACTURING CO. LOS ANGELES CALIFORNIA	
UNIT NO				



CALCULATED BY			ESTIMATED SUPERHEATER PRESSURE LOSS SUBCOOLER-SUPERHEATER 172210	AAC-4209-R CURVE 11
TRACED BY	STRASSEL	3-62		
CHECKED BY				
APPROVED BY			AIRESEARCH MANUFACTURING CO. LOS ANGELES, — CALIFORNIA	
UNIT NO.				



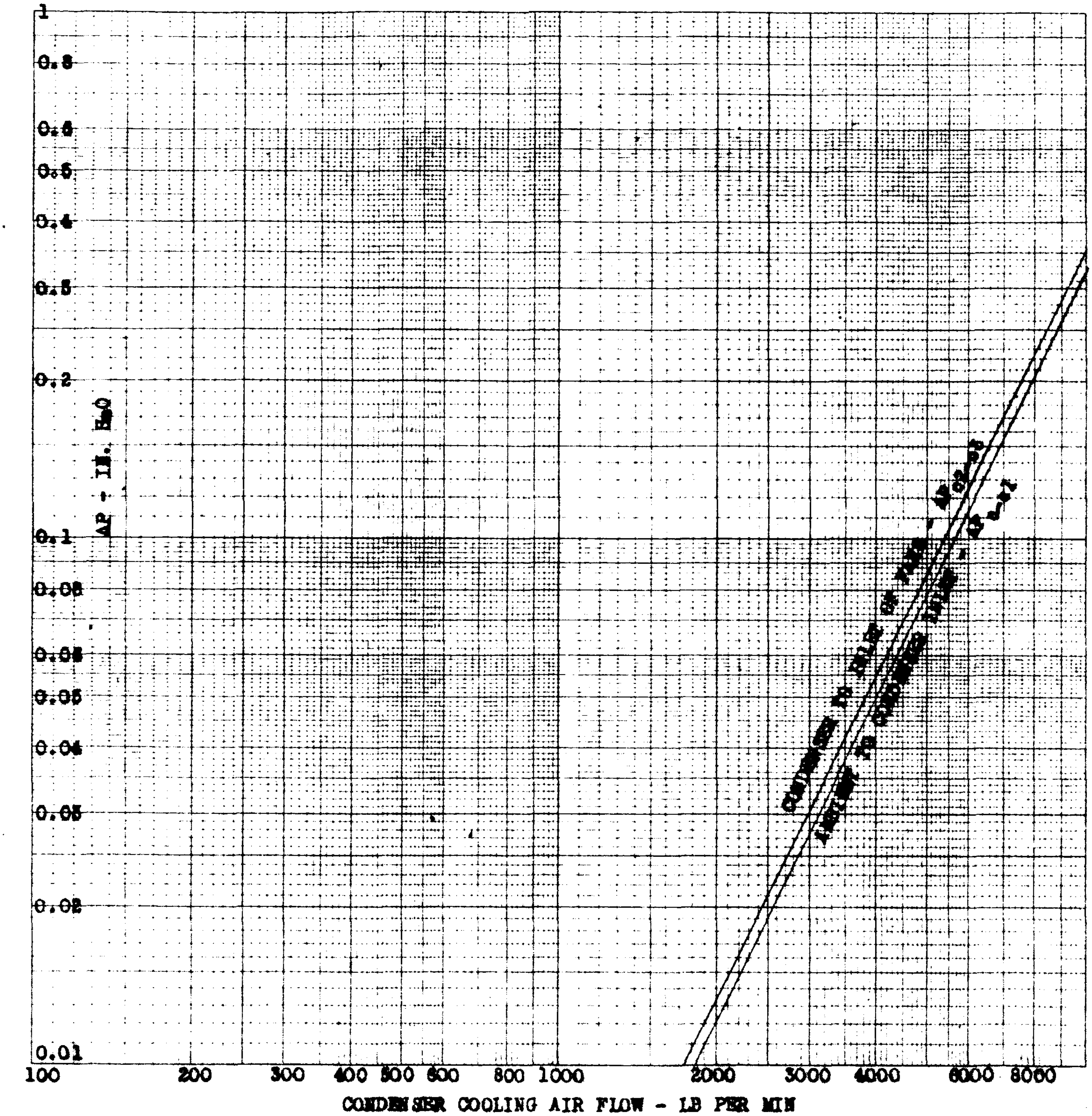
CALCULATED BY		
TRACED BY	Hildebrand	
CHECKED BY		6-42
APPROVED BY		
UNIT NO.		

PERFORMANCE OF
FREON COMPRESSOR 570420
WITH FREON F-114

AAC-4209-R
CURVE 12

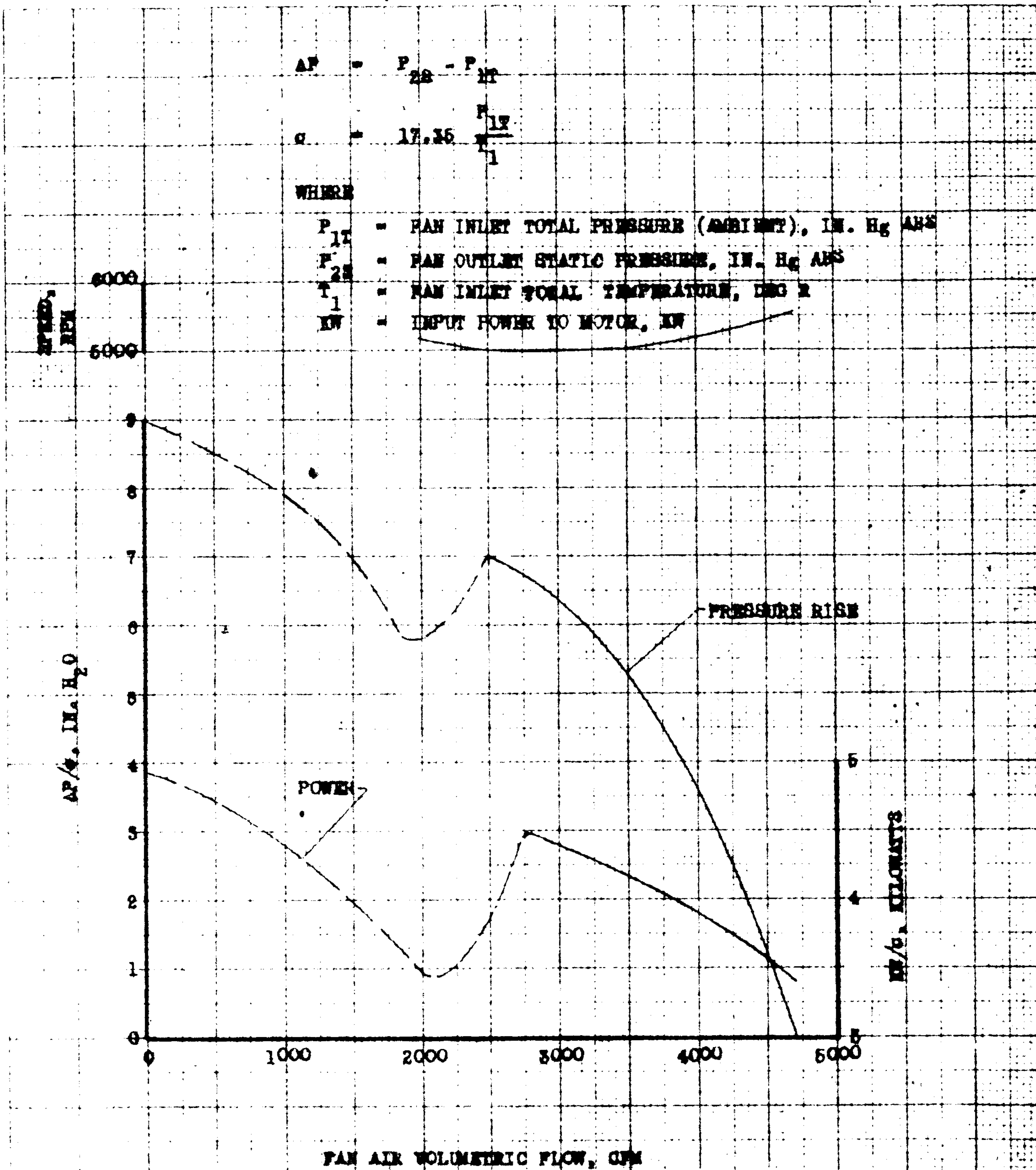
AIRESEARCH MANUFACTURING CO.
LOS ANGELES, — CALIFORNIA

(STATION POINTS AMBIENT -C1 and C2 - C3)



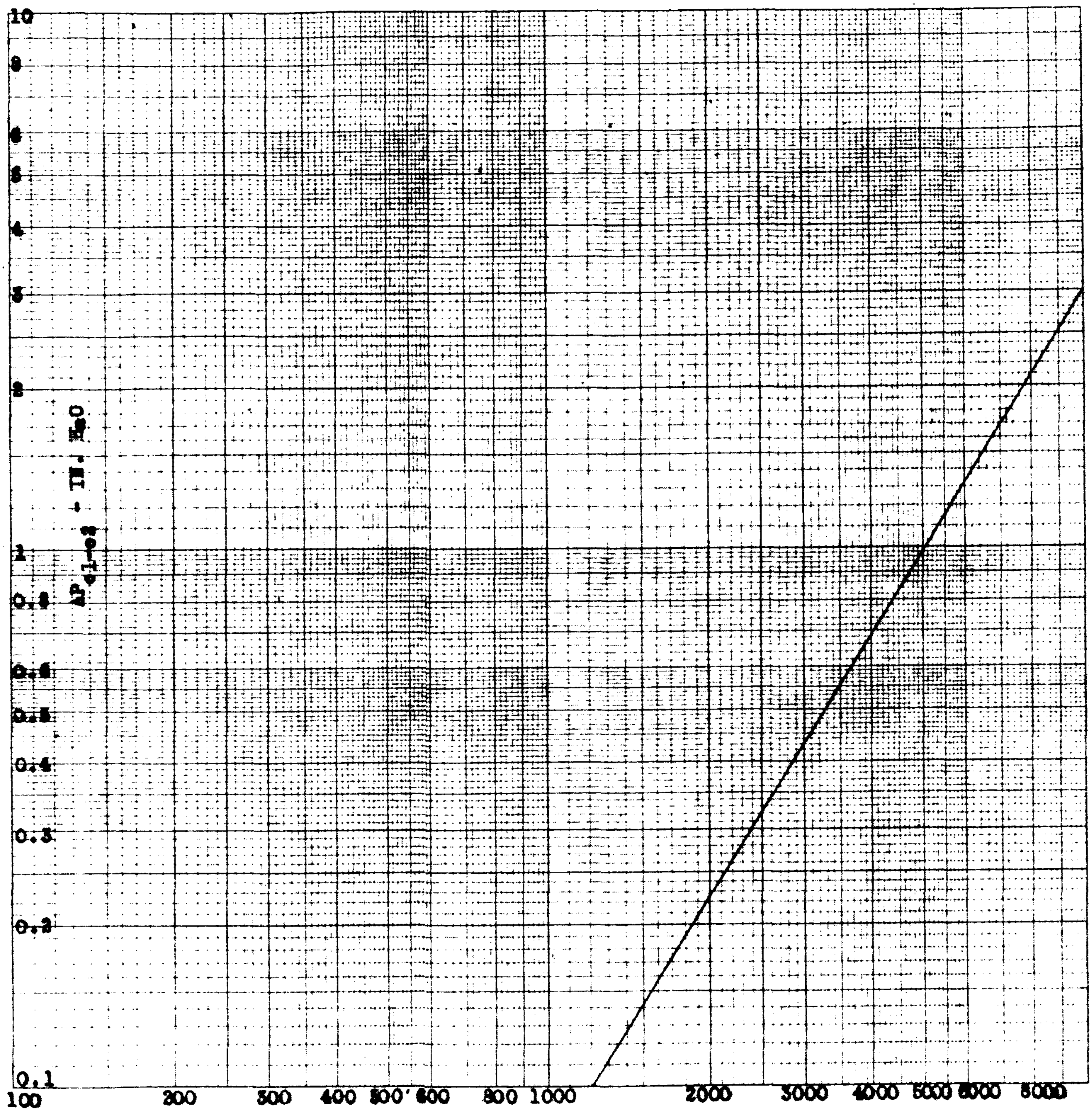
CALCULATED BY	STRASSEL	3-62	ESTIMATED PRESSURE LOSSES CONDENSER COOLING AIR CIRCUIT	AAC-4209-R CURVE 13
TRACED BY				
CHECKED BY				
APPROVED BY			AIRESEARCH MANUFACTURING CO. LOS ANGELES, — CALIFORNIA	
UNIT NO.				

(STATION POINTS C3-AMBIENT)



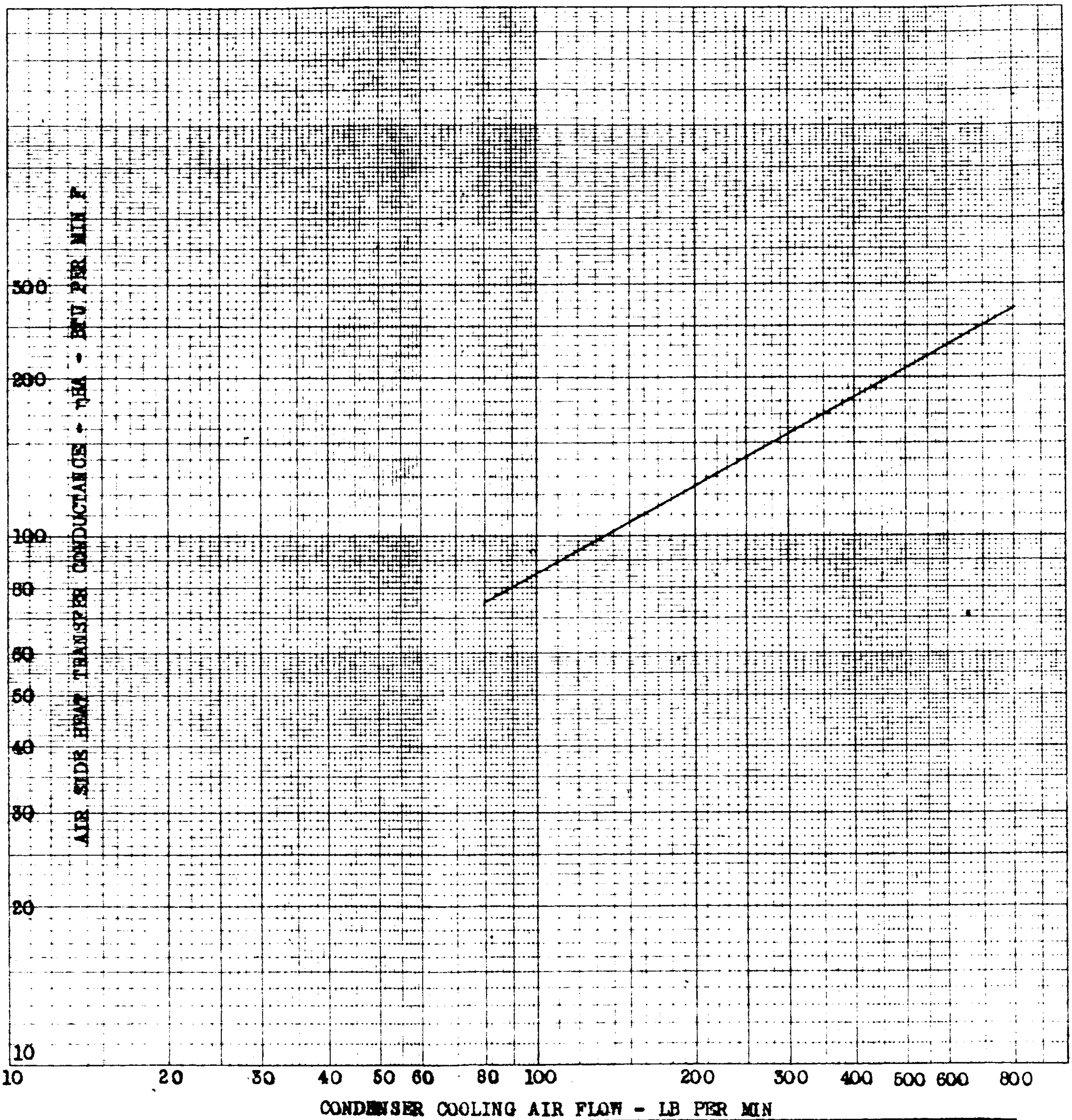
CALCULATED BY	KULUVA	11-60	PERFORMANCE OF CONDENSER FAN 207642-1	AAC-4209-R CURVE 14
TRACED BY	HILDEBRAND			
CHECKED BY				
APPROVED BY			AIRESEARCH MANUFACTURING CO. LOS ANGELES. — CALIFORNIA	
UNIT NO.				

(STATION POINTS C1 - C2)



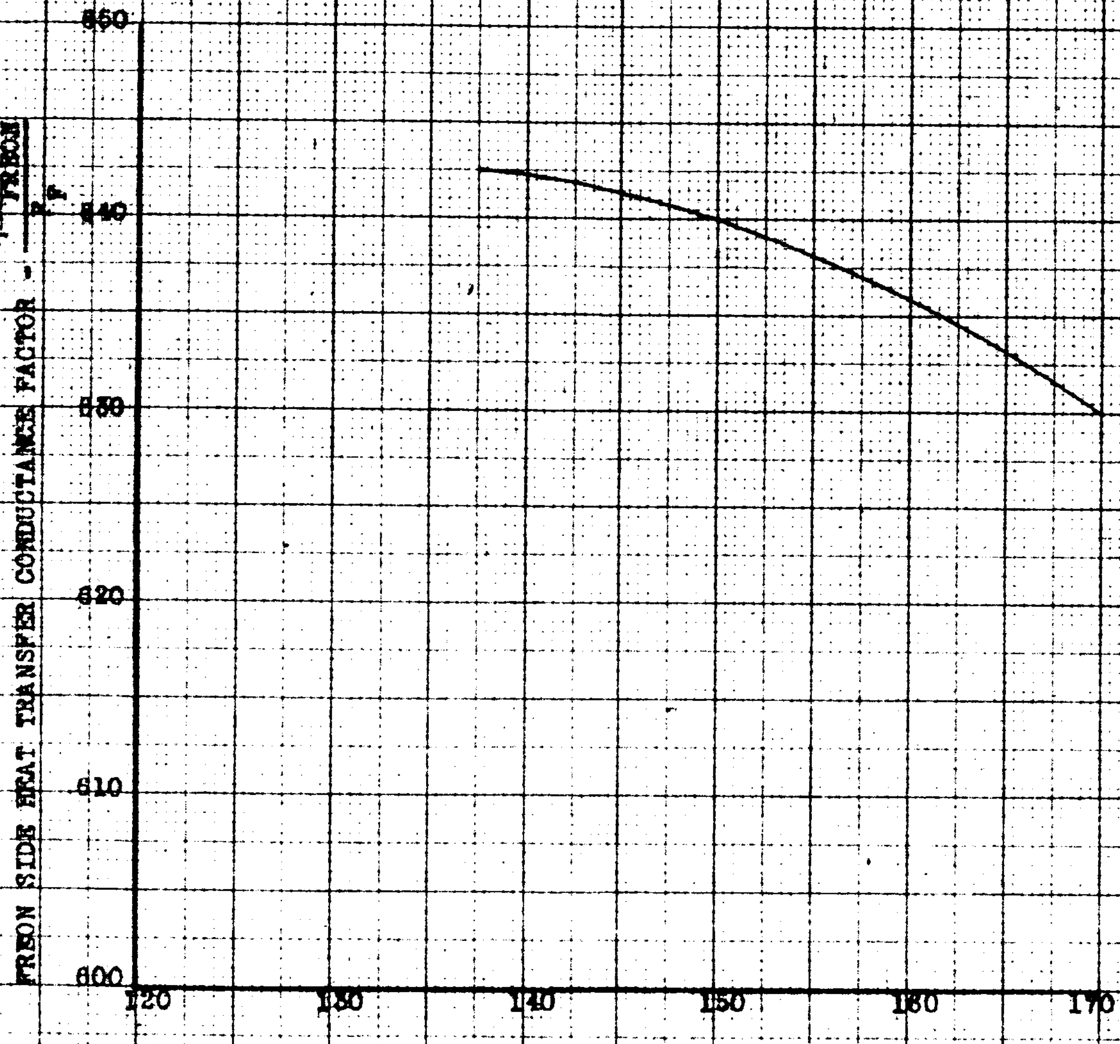
CALCULATED BY			ESTIMATED PERFORMANCE FREON 114 CONDENSER 174580	AAC-4209-R CURVE 15
TRACED BY	STRASSEL	3-62		
CHECKED BY				
APPROVED BY			AIRESEARCH MANUFACTURING CO. LOS ANGELES, — CALIFORNIA	
UNIT NO.				

(STATION POINTS C1 - C2)



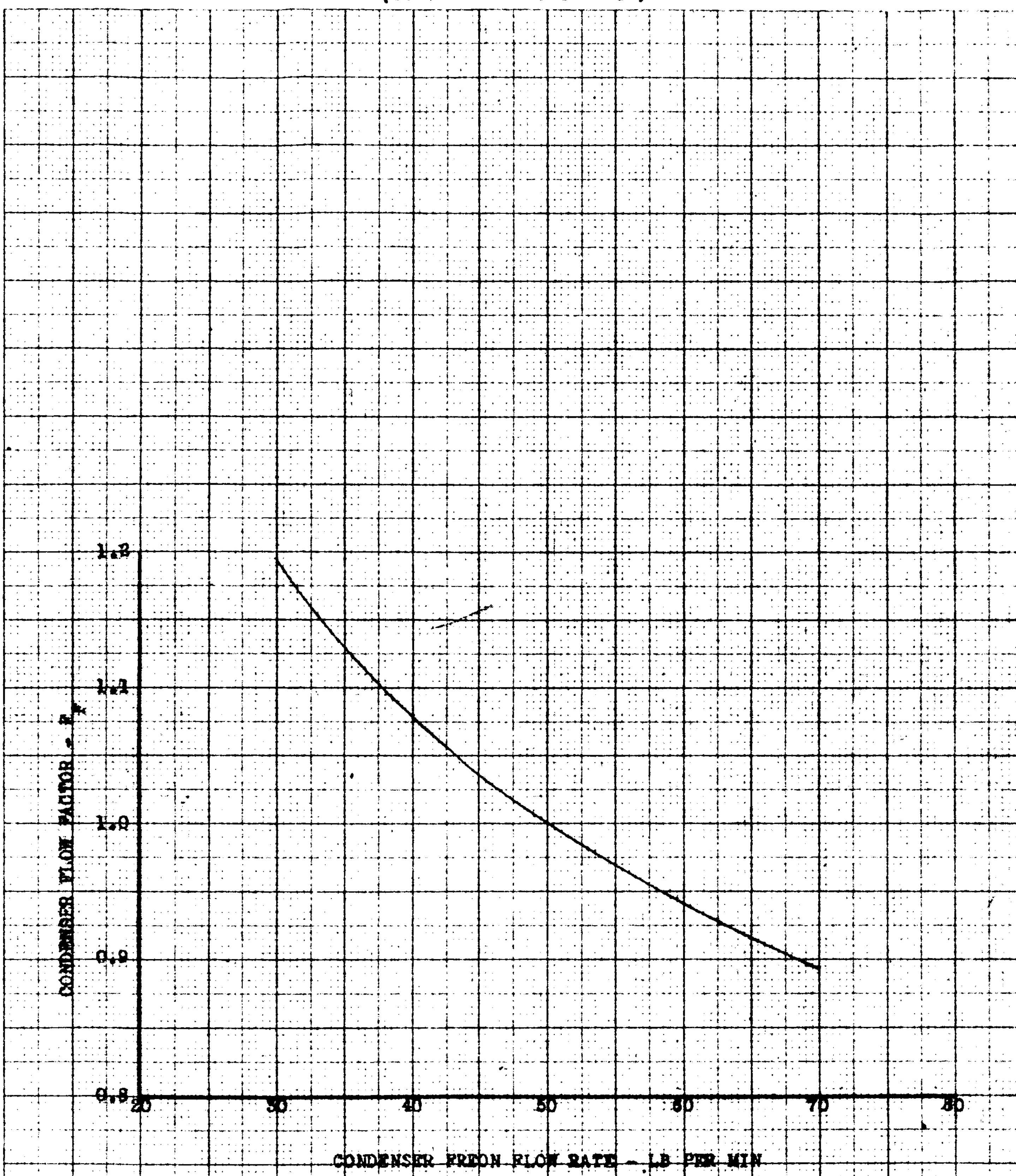
CALCULATED BY			ESTIMATED PERFORMANCE FREON 114 CONDENSER 174580	AAC-4209-R CURVE 16
TRACED BY	STRASSEL	3-62		
CHECKED BY				
APPROVED BY			AIRESEARCH MANUFACTURING CO. LOS ANGELES, — CALIFORNIA	
UNIT NO.				

(STATION POINTS C1 - C2)

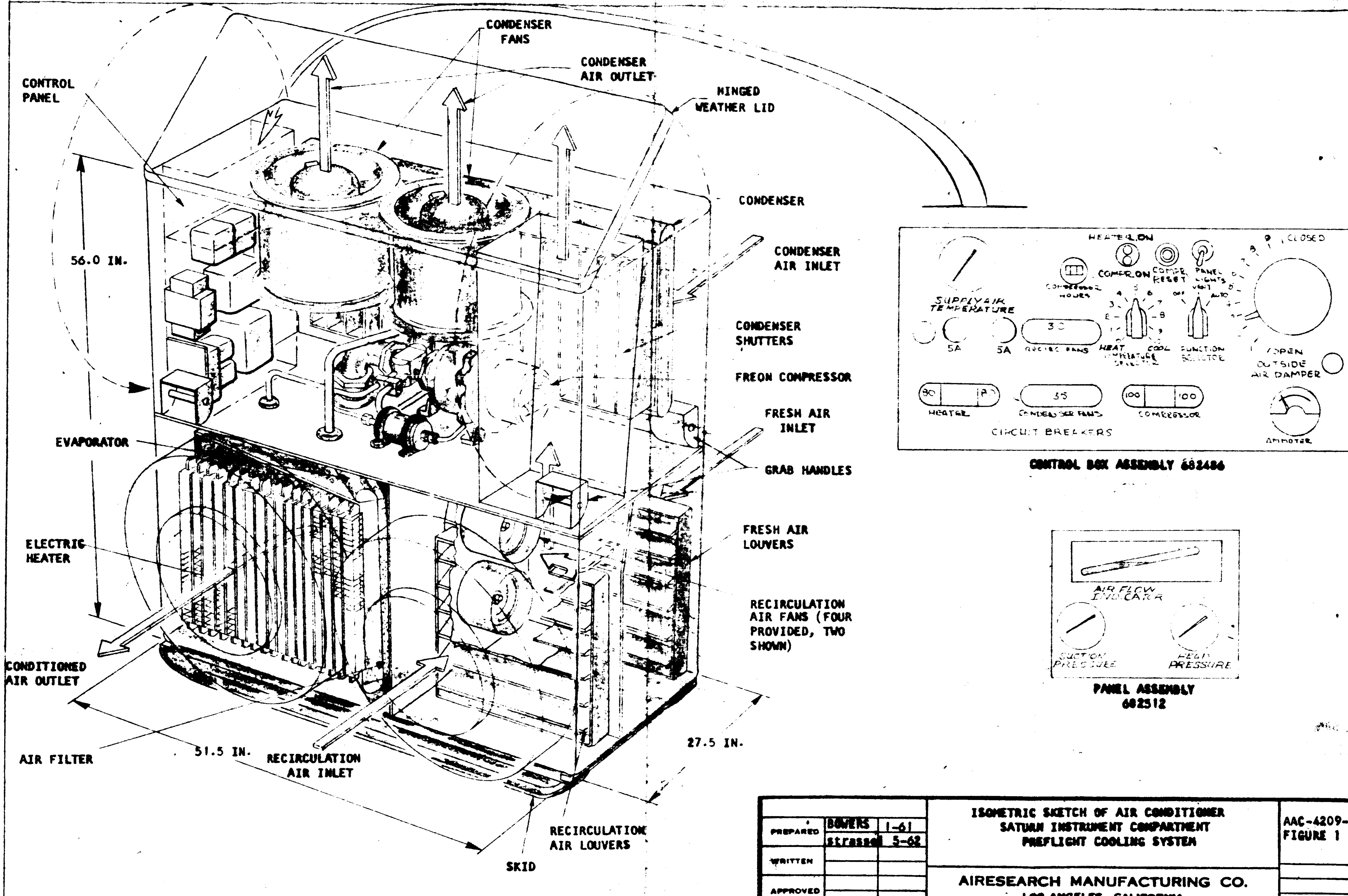


CALCULATED BY	ESTIMATED PERFORMANCE FREON 114 CONDENSER 174580	AAC-4209-R CURVE 17
TRACED BY		
CHECKED BY		
APPROVED BY	AIRESEARCH MANUFACTURING CO. LOS ANGELES CALIFORNIA	
UNIT NO		

(STATION POINTS C1 - C2)

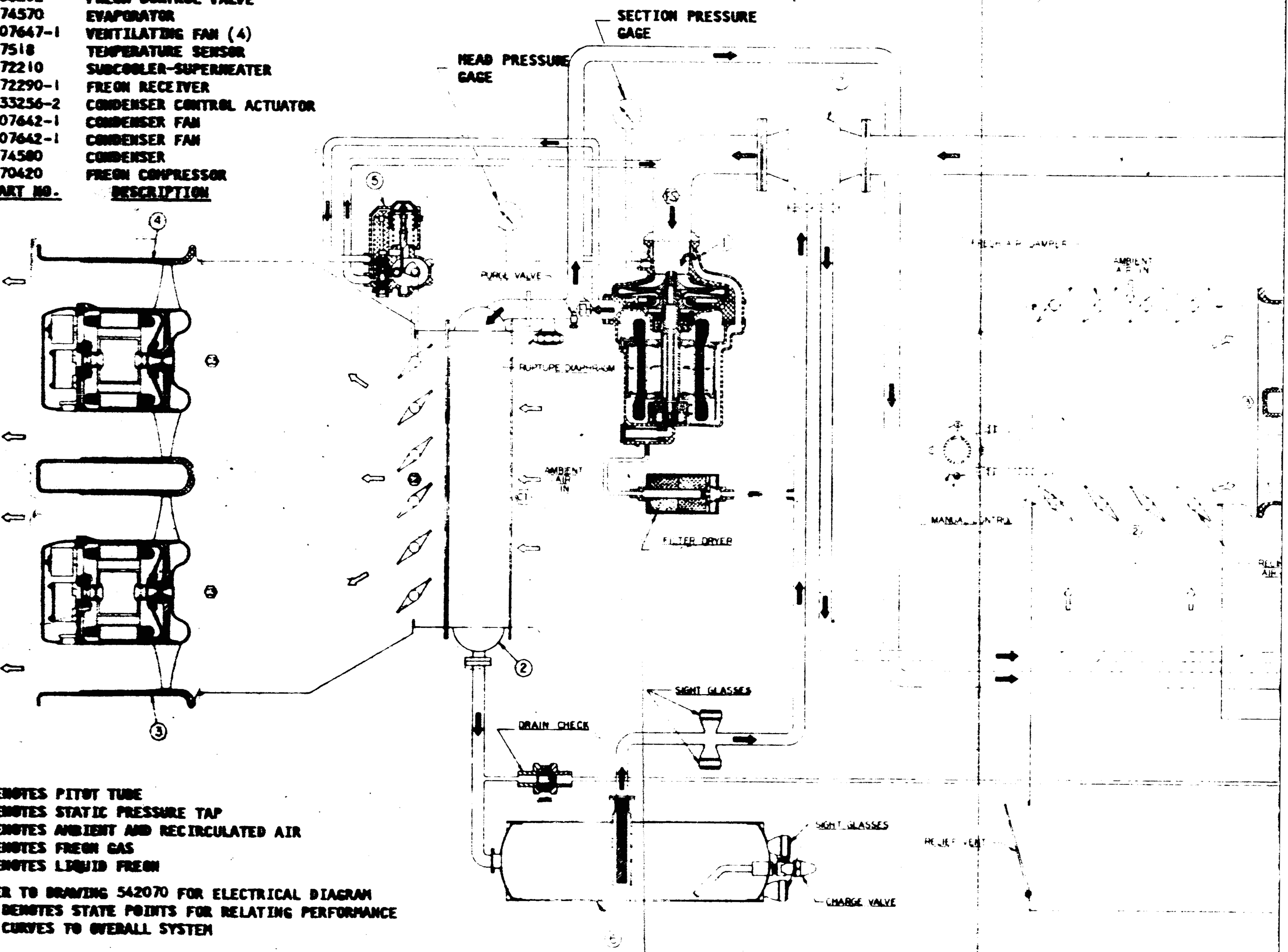


CALCULATED BY		ESTIMATED PERFORMANCE FREON 114 CONDENSER 174560	AAC-4209-R CURVE 18
TRACED BY			
CHECKED BY			
APPROVED BY		AIRESEARCH MANUFACTURING CO	
UNIT NO		LOS ANGELES CALIFORNIA	



			ISOMETRIC SKETCH OF AIR CONDITIONER SATURN INSTRUMENT COMPARTMENT PREFLIGHT COOLING SYSTEM	AAC-4209-R FIGURE 1
PREPARED	BOWERS	1-61		
	strassel	5-62		
WRITTEN				
APPROVED			AIRESEARCH MANUFACTURING CO. LOS ANGELES, CALIFORNIA	

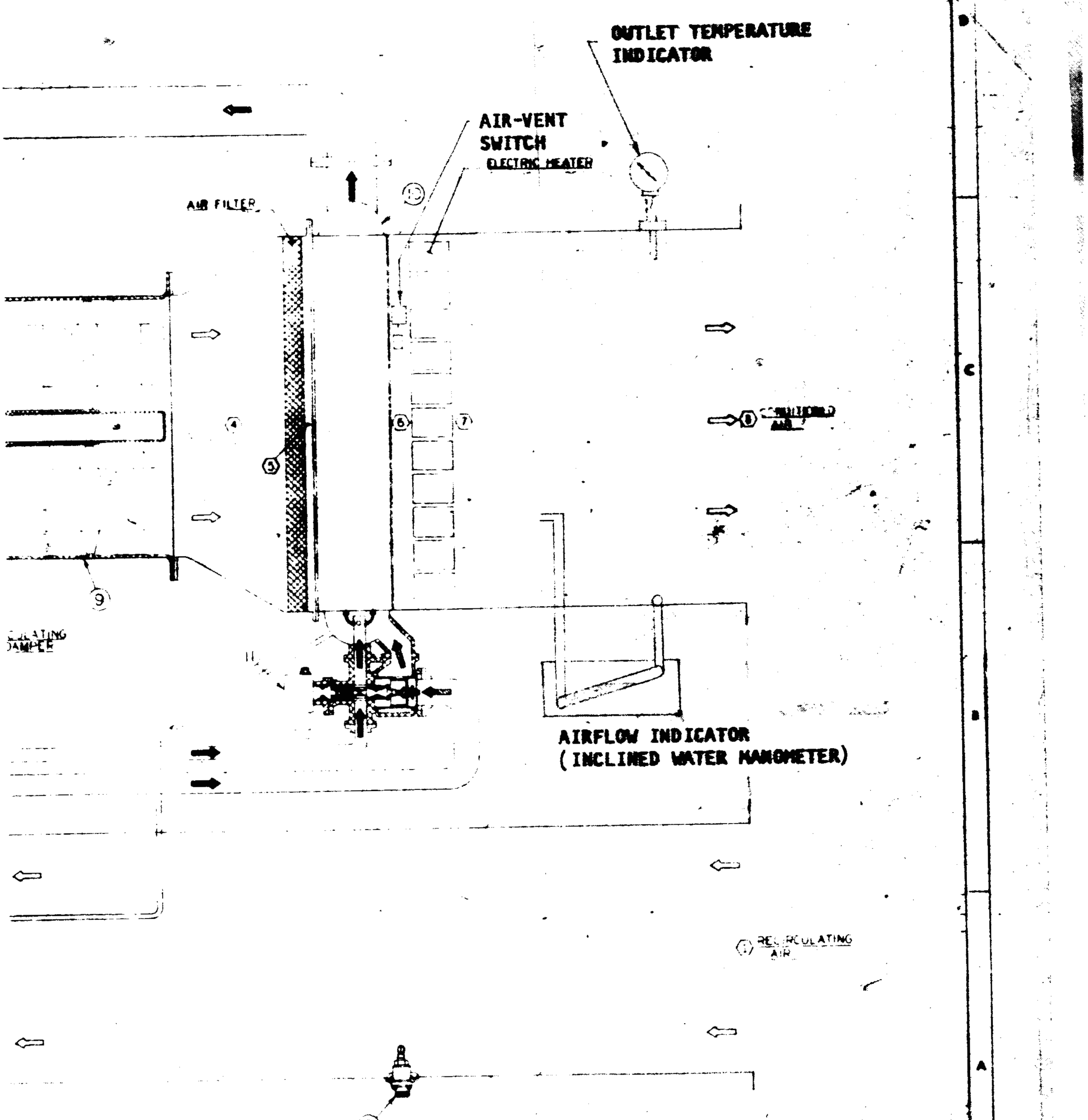
ITEM	PART NO.	DESCRIPTION
11	133202	FREON CONTROL VALVE
10	174570	EVAPORATOR
9	207647-1	VENTILATING FAN (4)
8	47518	TEMPERATURE SENSOR
7	172210	SUBCOOLER-SUPERHEATER
6	172290-1	FREON RECEIVER
5	133256-2	CONDENSER CONTROL ACTUATOR
4	207642-1	CONDENSER FAN
3	207642-1	CONDENSER FAN
2	174580	CONDENSER
1	570420	FREON COMPRESSOR



NOTES

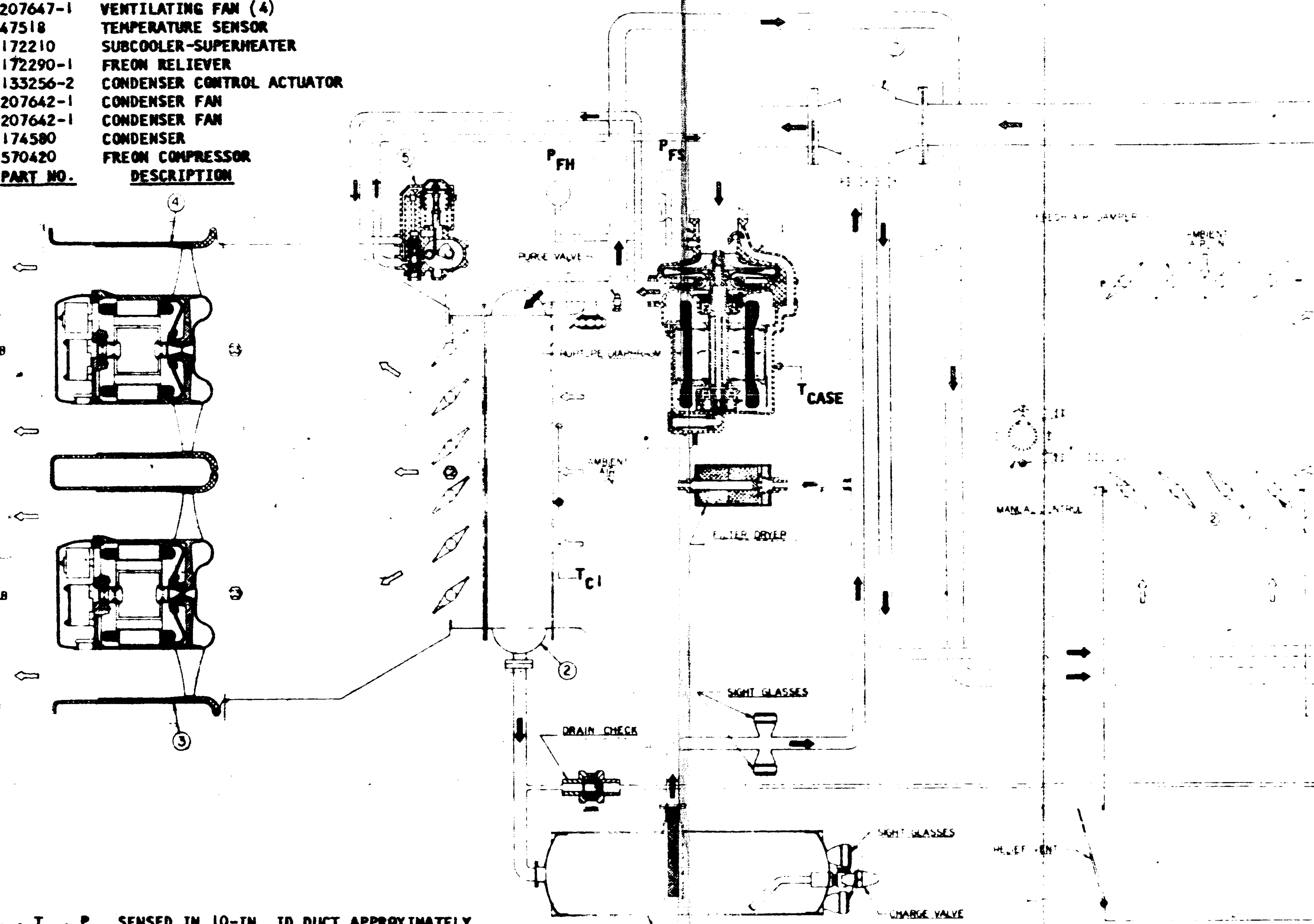
- DENOTES PITOT TUBE
- DENOTES STATIC PRESSURE TAP
- DENOTES AMBIENT AND RECIRCULATED AIR
- DENOTES FREON GAS
- DENOTES LIQUID FREON

(1) REFER TO DRAWING 542070 FOR ELECTRICAL DIAGRAM
(2) (1) DENOTES STATE POINTS FOR RELATING PERFORMANCE CURVES TO OVERALL SYSTEM



			SCHEMATIC DIAGRAM AIR CONDITIONER 682830-1 NASA SATURN MISSILE PREFLIGHT	AAC-4209-R FIGURE 2
PREPARED	Strassel	5-62		
WRITTEN			AIRESEARCH MANUFACTURING CO.	AAC-4209-R
APPROVED				

ITEM	PART NO.	DESCRIPTION
11	133202	FREON CONTROL VALVE
10	174570	EVAPORATOR
9	207647-1	VENTILATING FAN (4)
8	47518	TEMPERATURE SENSOR
7	172210	SUBCOOLER-SUPERHEATER
6	172290-1	FREON RELIEVER
5	133256-2	CONDENSER CONTROL ACTUATOR
4	207642-1	CONDENSER FAN
3	207642-1	CONDENSER FAN
2	174580	CONDENSER
1	570420	FREON COMPRESSOR



NOTES

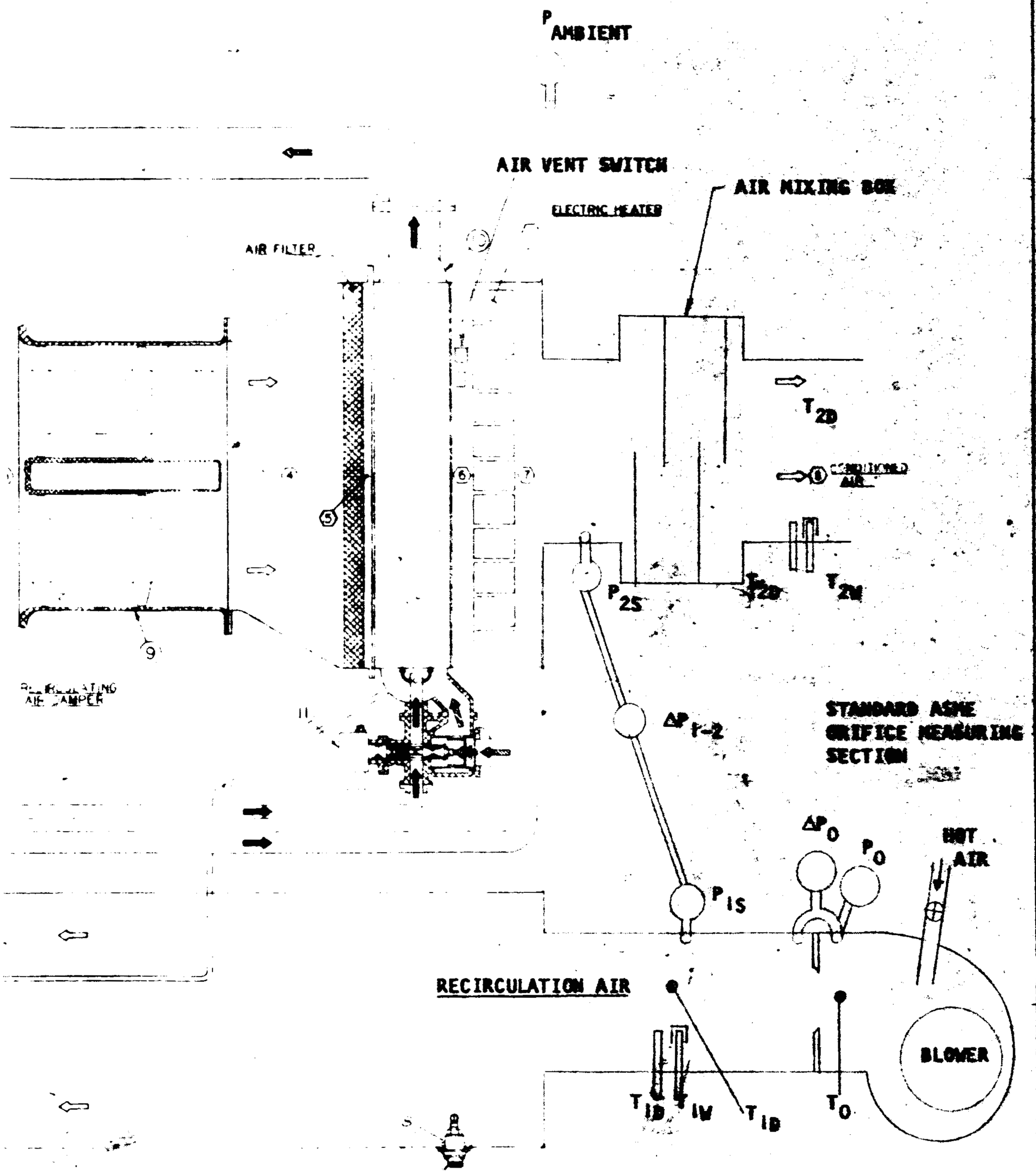
(1) T_{ID}, T_{IW}, P_{IS} SENSED IN 10-IN. ID DUCT APPROXIMATELY 12 IN. FROM UNIT FLANGE

(2) P_{2S} SENSED IN 10-IN. ID DUCT ABOUT 6 IN. FROM UNIT FLANGE

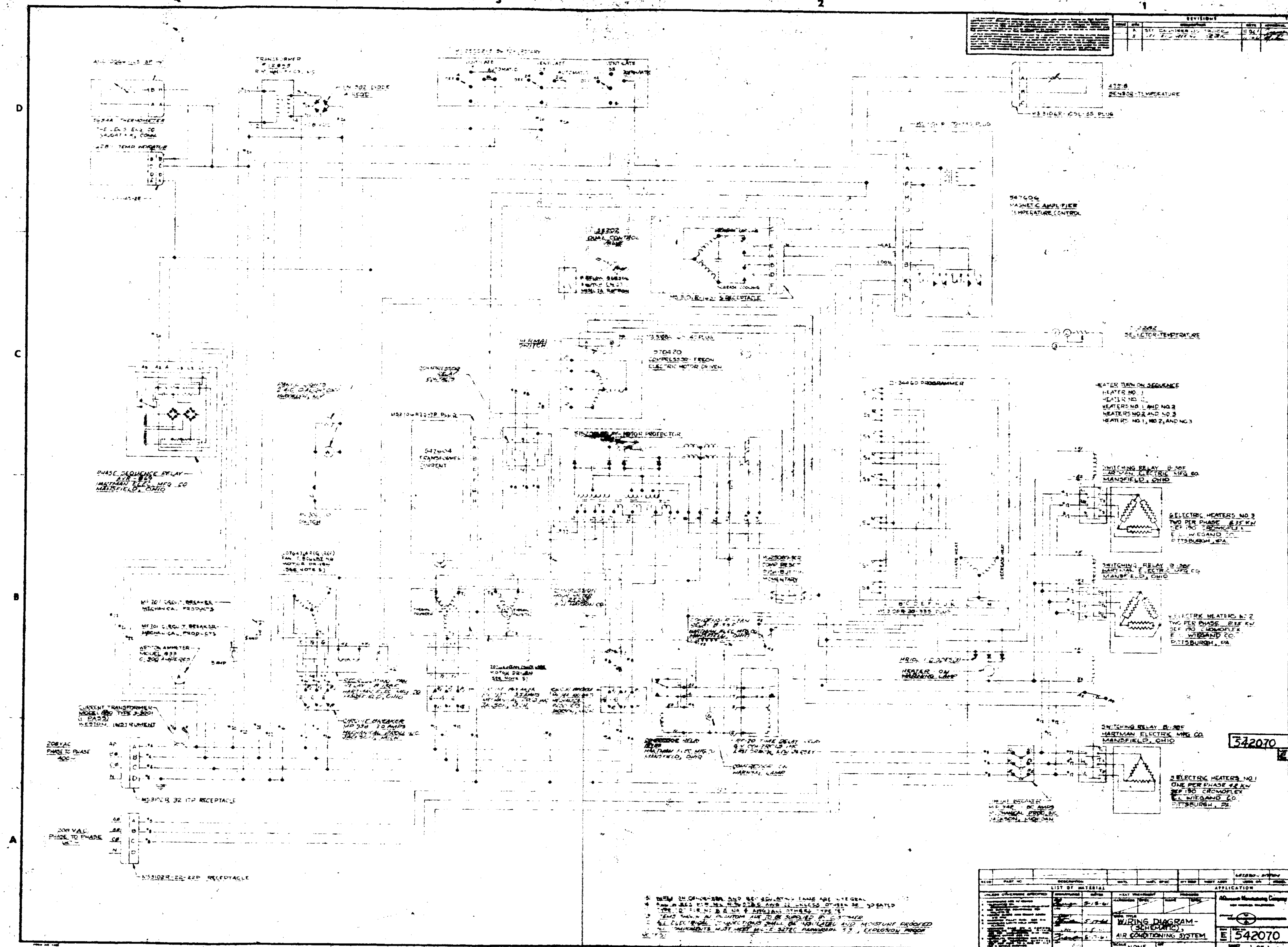
(3) T_{ID}, T_{IN}, T_{2D}, T_{2W} MEASURED BY PSYCHROMETER DURING PERFORMANCE TESTS. T_{ID} AND T_{2D} MEASURED BY THERMOCOUPLE DURING CALIBRATION RUNS

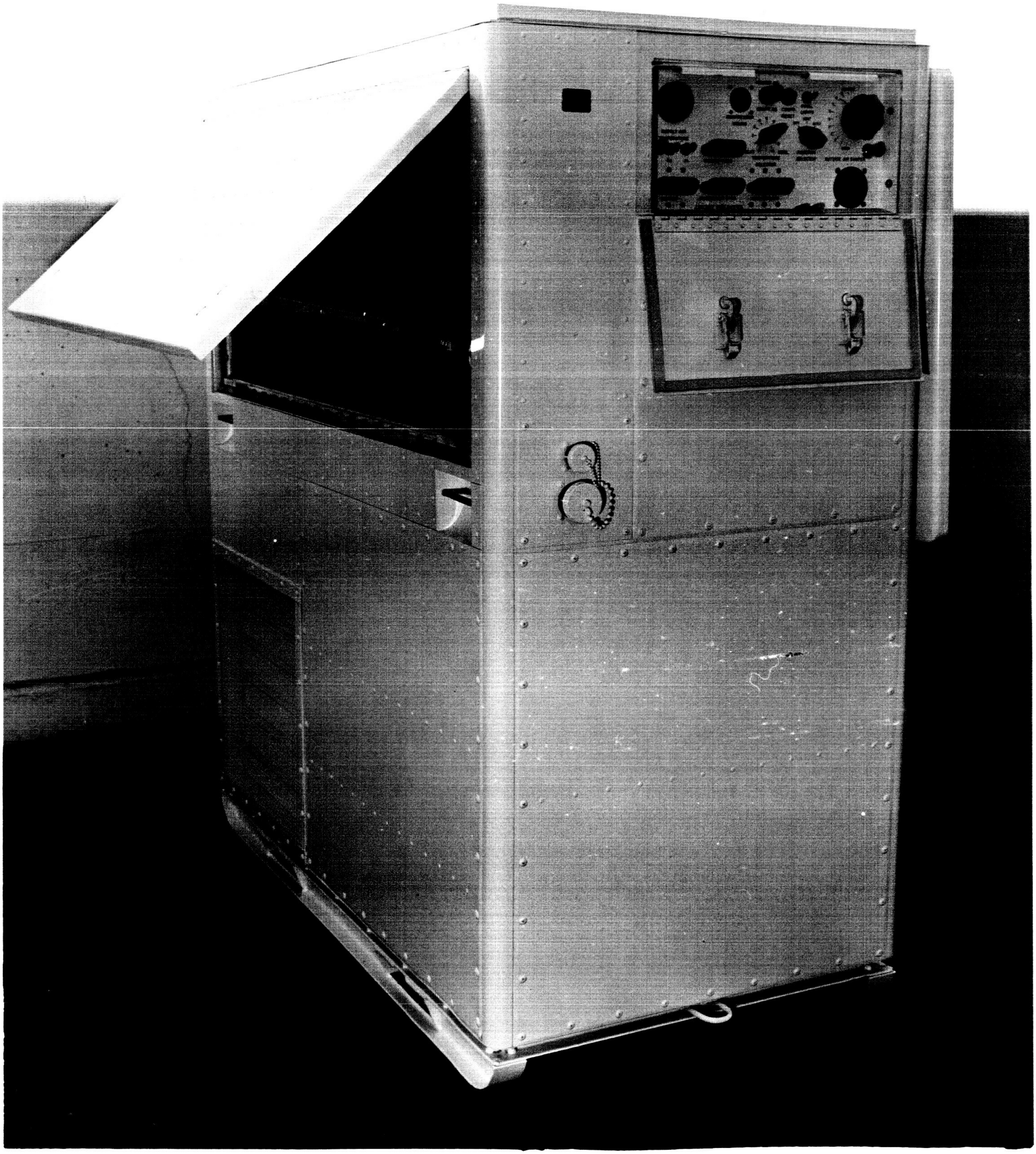
DENOTES DRY BULB THERMOMETER
DENOTES WET BULB THERMOMETER
DENOTES THERMOCOUPLE
DENOTES STATIC PRESSURE TAP

DENOTES AMBIENT AND RECIRCULATED AIR
DENOTES FREON GAS
DENOTES LIQUID FREON



PREPARED	Strassel	6-62	SCHEMATIC DIAGRAM FUNCTIONAL AND CALIBRATION TEST SETUP AIR CONDITIONER 682830-1, SERIAL 71-D1	AAC-4209-R FIGURE 3
WRITTEN				
APPROVED			AIRESEARCH MANUFACTURING CO. LOS ANGELES, CALIFORNIA	AAC-4209-R

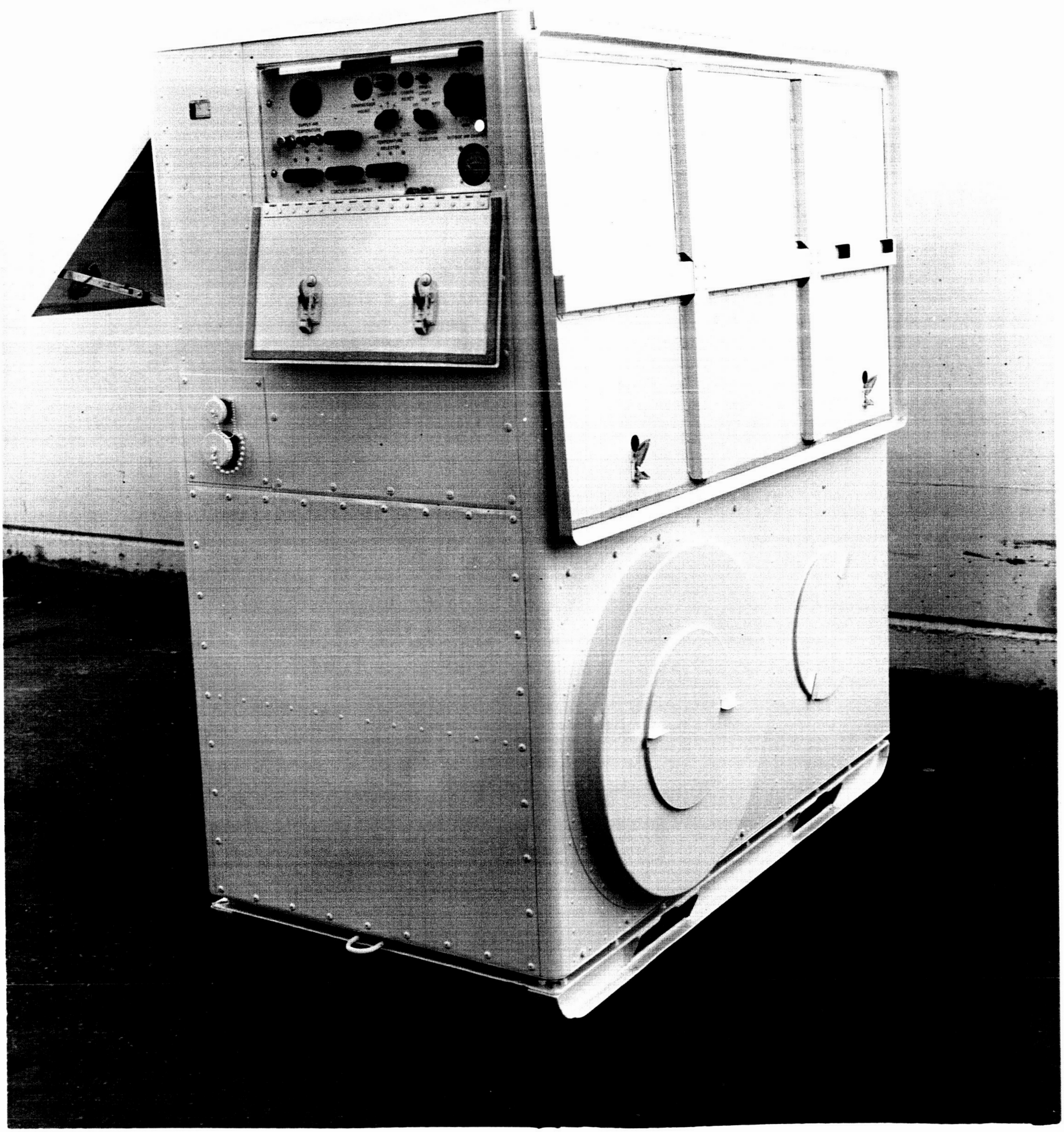

WIRING DIAGRAM-(SCHEMATIC) AIR CONDITIONING SYSTEM
E 542070
542070
HEATER TURN ON SEQUENCE
HEATER NO. 1
HEATER NO. 2
HEATERS NO. 1 AND NO. 2
HEATERS NO. 2 AND NO. 3
HEATERS NO. 1, NO. 2, AND NO. 3
3 ELECTRIC HEATERS NO. 1
ONE PER PHASE 4.2 KW
SWITCHING RELAY
HARTMAN ELECTRIC MFG. CO.
MANSFIELD, OHIO
547606
MAGNETIC AMPLIFIER
TEMPERATURE CONTROL
SELECTOR-TEMPERATURE
SENSOR-TEMPERATURE
PHASE SEQUENCE RELAY
COMPRESSOR-FREON
ELECTRIC MOTOR DRIVEN
MOTOR PROTECTOR
PROGRAMMER
208 VAC
PHASE TO PHASE
MS3102R 32-17P RECEPTACLE
MS3102R-20-22P RECEPTACLE
CURRENT TRANSFORMER
WESTON INSTRUMENT



AIR CONDITIONER 682830-1, S/N 71-D1
DATE: 11-21-61

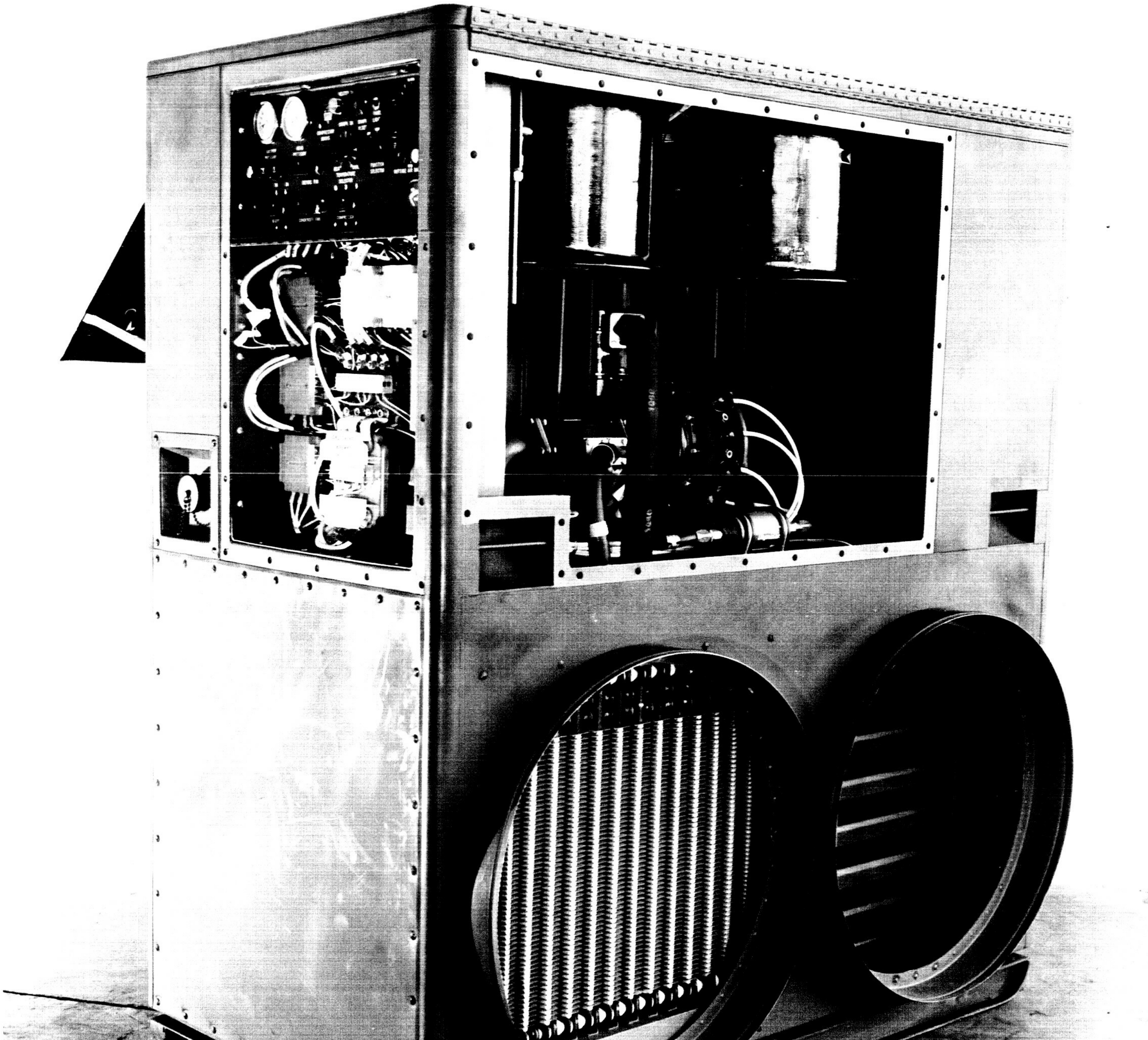
PHOTO 42753-1

THE GARRETT CORPORATION
AiResearch Manufacturing Division
LOS ANGELES 45, CALIFORNIA



AIR CONDITIONER 682830-1, S/N 71-D1
DATE: 11-21-61

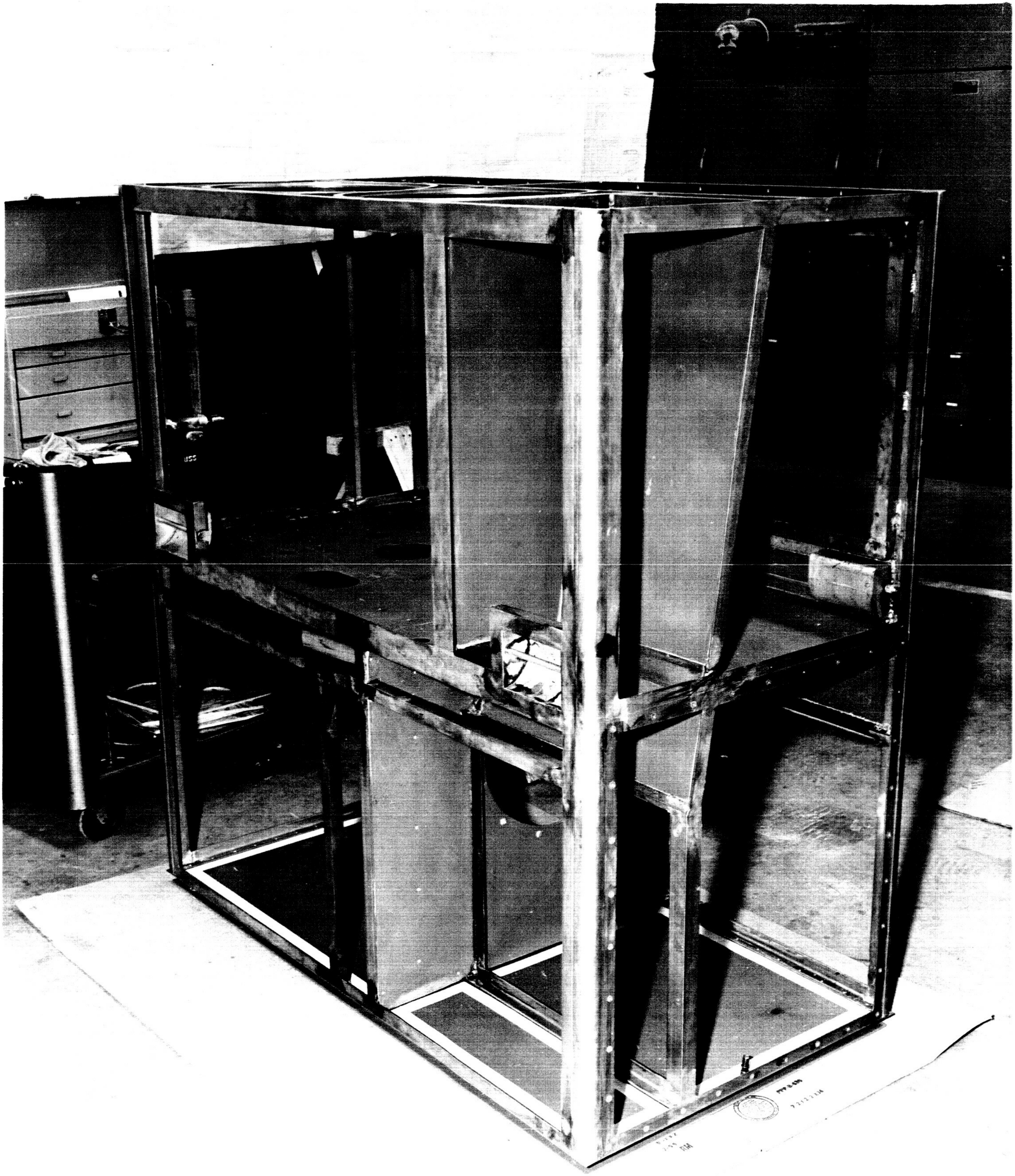
PHOTO 42753-2



AIR CONDITIONER 174560, S/N 1
DATE: 5-20-60

PHOTO 39089-4

THE GARRETT CORPORATION
AiResearch Manufacturing Division
LOS ANGELES 45, CALIFORNIA



PART NOS. 174560, 682085
PRODUCTION
EWO 340-200073-01-0100
DATE: 3-9-60

PHOTO 38443-5

THE GARRETT CORPORATION
AiResearch Manufacturing Division
LOS ANGELES 45, CALIFORNIA

APPENDIX II

ROTOTEST LABORATORIES REPORT 3124

EXPLOSION TESTING OF STRIP HEATER

115 VOLT, 900 WATT

Service To: AiResearch Manufacturing Company 9851-9951 Sepulveda Boulevard Los Angeles 45, California	**Report No.** 3124 **Purchase Order No.** 9-28746-1 **Contract No.** NASA 1578 **Date** July 5, 1961

CERTIFIED TEST REPORT

EXPLOSION TESTING

OF

STRIP HEATER, 115 VOLT, 900 WATT

rototest laboratories
2803 Los Flores Boulevard
Lynwood, California
NEvada 6-9238

COUNTY OF LOS ANGELES } SS
STATE OF CALIFORNIA

Vern L. Sandberg, Laboratory Supervisor, being duly sworn, deposes and says: That the information contained in this report is the result of complete and carefully conducted tests and is to the best of his knowledge true and correct in all respects.

Vern L. Sandberg

SUBSCRIBED and sworn to before me this 5th day of July, 1961

Ruby T. Archambault

Notary Public in and for the County of Los Angeles, State of California.
My commission expires October 2, 1962

Tests Conducted By:
Albert G. Kleinknecht Albert G. Kleinknecht

Certified By: Andrew McKendry
Quality Control Engineer

Form QC-11
1/1/59

rototest laboratories, inc.
2803 Los Flores Boulevard
Lynwood, California
NEvada 6-9238

ADMINISTRATIVE DATA

DATE: JULY 5, 1961

NAME OF PART: STRIP HEATER, 115 VOLT, 900 WATT

PURPOSE OF TEST: EXPLOSION TESTING

MANUFACTURER: --

MANUFACTURER'S TYPE OR PART NO.: --

DRAWING, SPECIFICATION OR EXHIBIT: MIL-E-5272C

QUANTITY OF ITEMS TESTED: ONE (1) SAMPLE

SECURITY CLASSIFICATION OF ITEMS: UNCLASSIFIED

DATA TEST COMPLETED: JUNE 28, 1961

TEST CONDUCTED BY: ROTOTEST LABORATORIES, INC.

DISPOSITION OF SPECIMENS: THE SAMPLE WAS RETURNED TO AIRESEARCH MANUFACTURING CO.

SIGNATURES:

Vern L. Sandberg
VERN L. SANDBERG
LABORATORY SUPERVISOR

ABSTRACT:

1. EXPLOSION

SAMPLE 1

REFERENCE: MIL-E-5272C(ASG) AMENDMENT I DATED 20 JANUARY 1960, PARAGRAPHS 4.13, 4.13.3, 4.13.3.1, 4.13.4, 4.13.4.1, 4.13.4.2, 4.13.4.3

REQUIREMENT: MIL-E-5272C(ASG)

"4.13 EXPLOSION TESTS (SEE 5.3 AND 5.4.4). - "

"4.13.3 APPARATUS. - AN EXPLOSION CHAMBER EQUAL TO MIL-C-9435 SHALL BE UTILIZED FOR CONDUCTING EXPLOSION-PROOF TESTS."

"4.13.3.1 FUEL. - FUEL USED SHALL BE GASOLINE, GRADE 100/130, CONFORMING TO MIL-G-5572."

"4.13.4 PROCEDURE III. -"

"4.13.4.1 PURPOSE. - THE FOLLOWING PROCEDURE SHALL BE USED TO DETERMINE THE EXPLOSION PRODUCING CHARACTERISTICS OF ITEMS OF EQUIPMENT NOT EQUIPPED WITH CASES DESIGNED TO PREVENT FLAME OR EXPLOSION PROPAGATION."

"4.13.4.2 PREPARATION FOR TEST. -

A. THE EQUIPMENT TO BE TESTED SHALL BE INSTALLED IN THE TEST CHAMBER IN SUCH A MANNER THAT NORMAL ELECTRICAL OPERATION IS POSSIBLE AND MECHANICAL CONTROLS MAY BE OPERATED THROUGH THE PRESSURE SEALS FROM THE EXTERIOR OF THE CHAMBER. ALL EXTERNAL COVERS OF THE TEST ITEM SHALL BE REMOVED OR OPENED TO INSURE ADEQUATE CIRCULATION OF THE EXPLOSIVE MIXTURE. LARGE EQUIPMENT MAY BE TESTED ONE OR MORE UNITS AT A TIME BY EXTENDING ELECTRICAL CONNECTIONS THROUGH THE CABLE PORT TO THE BALANCE OF THE EQUIPMENT LOCATED EXTERNALLY.

B. THE EQUIPMENT SHALL BE OPERATED TO DETERMINE THAT IT IS FUNCTIONING PROPERLY AND TO OBSERVE THE LOCATION OF ANY SPARKING OR HIGH TEMPERATURE COMPONENTS WHICH MAY CONSTITUTE POTENTIAL EXPLOSION HAZARDS.

C. MECHANICAL LOADS ON DRIVE ASSEMBLIES AND SERVOMECHANICAL AND ELECTRICAL LOADS ON SWITCHES AND RELAYS MAY BE SIMULATED WHEN NECESSARY IF PROPER PRECAUTION IS GIVEN TO DUPLICATING THE NORMAL LOAD IN RESPECT TO TORQUE, VOLTAGE, CURRENT, INDUCTIVE REACTANCE, ETC. IN ALL INSTANCES IT SHALL BE CONSIDERED PREFERABLE TO OPERATE THE EQUIPMENT AS IT NORMALLY FUNCTIONS IN THE SYSTEM DURING SERVICE USE."

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1. EXPLOSION - CONTINUED

REQUIREMENT: - CONTINUED

MIL-E-5272C(ASG) - CONTINUED

"4.13.4.3 TEST PROCEDURES. -

A. A TEST SHALL BE CONDUCTED AS FOLLOWS:

(1) THE TEST CHAMBER SHALL BE SEALED AND THE AMBIENT TEMPERATURE WITHIN SHALL BE RAISED TO +71 ±3°C (+160 ±5° F), OR TO THE MAXIMUM TEMPERATURE TO WHICH THE EQUIPMENT IS DESIGNED TO OPERATE (IF LOWER THAN 160° F). THE TEMPERATURE OF THE TEST ITEM AND THE CHAMBER WALLS SHALL BE PERMITTED TO RISE TO WITHIN 11° C (20° F) OF THAT OF THE CHAMBER AMBIENT AIR, PRIOR TO INTRODUCTION OF THE EXPLOSIVE MIXTURE.

(2) THE INTERNAL TEST CHAMBER PRESSURE SHALL BE REDUCED SUFFICIENTLY TO SIMULATE AN ALTITUDE APPROXIMATELY 10,000 FEET ABOVE THE DESIRED TEST ALTITUDE. THE WEIGHT OF FUEL NECESSARY TO PRODUCE AN AIR-VAPOR RATIO OF 13 TO 1 AT THE DESIRED TEST ALTITUDE SHALL BE DETERMINED FROM CONSIDERATION OF CHAMBER VOLUME, FUEL TEMPERATURE AND SPECIFIC GRAVITY, CHAMBER AIR AND WALL TEMPERATURE, TEST ALTITUDE, ETC. (SEE 5.4.4.4). A TIME OF 3 ±1 MINUTES SHALL BE ALLOWED FOR INTRODUCTION AND VAPORIZATION OF THE FUEL. AIR SHALL BE ADMITTED INTO THE CHAMBER UNTIL A SIMULATED ALTITUDE OF 5,000 FEET ABOVE THE TEST ALTITUDE IS ATTAINED. AT THIS TIME THE POTENTIAL EXPLOSIVENESS OF THE RESULTING AIR-VAPOR MIXTURE SHALL BE VERIFIED BY A SAMPLING METHOD WHICH HAS BEEN APPROVED BY THE PROCURING ACTIVITY.

(3) OPERATION OF THE TEST ITEM SHALL AT THIS TIME BE COMMENCED, ALL MAKING AND BREAKING ELECTRICAL CONTACTS BEING ACTUATED. IF HIGH TEMPERATURE COMPONENTS ARE PRESENT, A WARM-UP TIME OF 15 MINUTES SHALL BE PERMITTED. IF NO EXPLOSION RESULTS, AIR SHALL BE ADMITTED INTO THE CHAMBER SO AS TO STEADILY REDUCE THE ALTITUDE DOWN PAST THE DESIRED TEST ALTITUDE TO AN ELEVATION OF 5,000 FEET BELOW THAT ALTITUDE OR AS CLOSE THERETO AS PERMITTED BY LOCAL GROUND LEVEL ALTITUDE. THE OPERATION OF THE TEST ITEM SHALL BE CONTINUOUS THROUGHOUT THIS PERIOD OF ALTITUDE REDUCTION AND ALL MAKING AND BREAKING ELECTRICAL CONTACTS SHALL BE OPERATED AS FREQUENTLY AS POSSIBLE.

1. EXPLOSION - CONTINUED

REQUIREMENT: - CONTINUED

MIL-E-5272C(ASG) - CONTINUED

4.13.4.3 - CONTINUED

(4) IF BY THE TIME THE SIMULATED ALTITUDE HAS BEEN REDUCED TO 5,000 FEET BELOW THE TEST ALTITUDE, NO EXPLOSION HAS OCCURRED AS A RESULT OF OPERATION OF THE EQUIPMENT UNDER TEST, THE POTENTIAL EXPLOSIVENESS OF THE AIR-VAPOR MIXTURE SHALL AGAIN BE VERIFIED BY A SAMPLING METHOD WHICH HAS BEEN APPROVED BY THE PROCURING ACTIVITY. IF THE AIR-VAPOR MIXTURE IS NOT FOUND TO BE EXPLOSIVE AT THIS TIME, THE TEST SHALL BE CONSIDERED VOID AND THE ENTIRE PROCEDURE REPEATED.

B. THE ABOVE-DESCRIBED TEST SHALL BE ACCOMPLISHED AT SIMULATED TEST ALTITUDES OF LOCAL GROUND LEVEL TO 5,000 FEET, 10,000, 20,000, 30,000, 40,000, AND 50,000 FEET, UNLESS AN EXPLOSION IS CAUSED BY THE TEST ITEM DURING A TEST, IN WHICH CASE THE ITEM SHALL BE CONSIDERED TO HAVE FAILED TO PASS THE TEST AND NO FURTHER TRIALS NEED BE ATTEMPTED."

PROCEDURE: THIS TEST WAS PERFORMED IN ACCORDANCE WITH THE REQUIREMENTS OF MIL-E-5272C. DURING THE TEST THE SAMPLE WAS ENERGIZED WITH 115 VOLTS, 60 CPS. AT EACH ALTITUDE, THE SAMPLE WAS ENERGIZED AND DEENERGIZED TEN TIMES. CHAMBER TEMPERATURE WAS MAINTAINED AT 160±5°F

EQUIPMENT:

TO MEASURE	SYMBOL	UNIT	APPARATUS
AMBIENT TEMPERATURE	TA	°F	UNITED CONTROLS TEMPERATURE GAGE, RTL No. F-7062, 0/350 x 5°F
BAROMETRIC PRESSURE	PRESS B	IN.HG	U. S. WEATHER BUREAU
GAGE PRESSURE	PRESS G	IN.HG	MERIAM MERCURY MANOMETER, RTL No. 2903, 0/25 x 0.1 INCH
ABSOLUTE PRESSURE	PA	IN.HG	CALCULATED: PA = PRESS B - PRESS G
INPUT VOLTAGE TO SAMPLE	E	VOLT	QUALITY ELECTRIC, MODEL 10, S.N. 3044, 0/150 x 2 VOLTS A.C.
INPUT FREQUENCY	FREQ	CPS	COMMERCIAL LINE FREQUENCY

rototest laboratories, inc.
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Lynwood, California
NEvada 6-9238

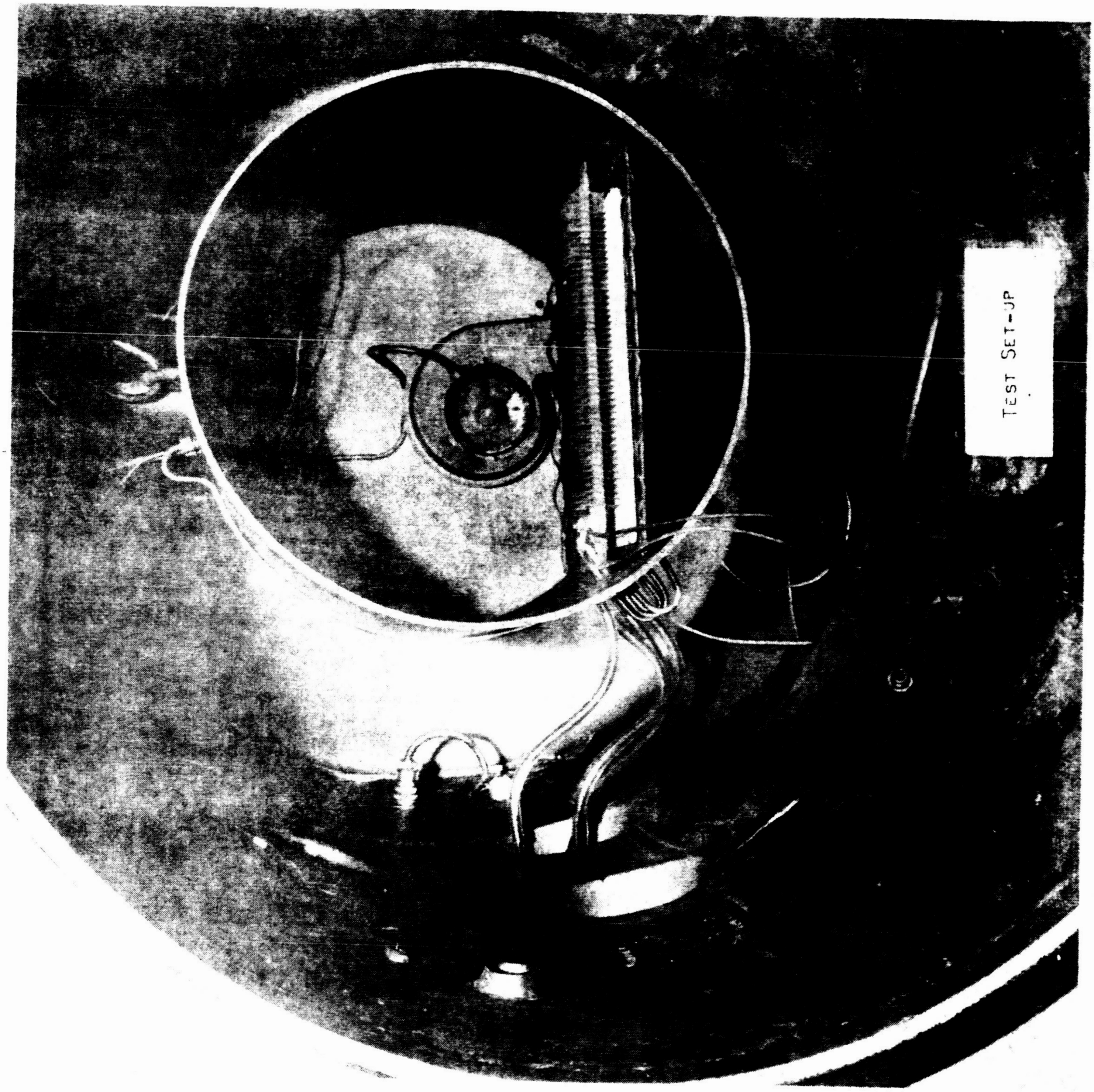
1. EXPLOSION - CONTINUED

RESULTS:

DATE 1961	TIME	TA °F	PRESS B IN.HG	PRESS G IN.HG	PA IN.HG	E VOLT	FREQ CPS	SAMPLE	COMMENT
SEA LEVEL						115	60	1	SPECIFIED
[illegible]	1:30	[illegible]	30.00	0	30.00	115	60	1	EXPLOSIVE VAPORS ADDED; SAMPLE OPERATED; NO EXPLOSION.
10,000 FEET									
	1:45	156	30.00	9.34	20.66	115	60		EXPLOSIVE VAPORS ADDED; SAMPLE OPERATED; NO EXPLOSION.
20,000 FEET									
	1:55	156	30.00	16.17	13.83	115	60		EXPLOSIVE VAPORS ADDED; SAMPLE OPERATED; NO EXPLOSION.
30,000 FEET									
	2:[illegible]	[illegible]	30.00	21.04	8.96	[illegible]	60		EXPLOSIVE VAPORS ADDED; SAMPLE OPERATED; NO EXPLOSION.
40,000 FEET									
	2:10	[illegible]	30.00	24.38	5.62	115	60		EXPLOSIVE VAPORS ADDED; SAMPLE OPERATED; NO EXPLOSION.
50,000 FEET									
	2:20	164	30.00	26.48	3.52	115	60		EXPLOSIVE VAPORS ADDED; SAMPLE OPERATED; NO EXPLOSION.

NOTE: THE EXPLOSIVENESS OF THE AIR-FUEL MIXTURE WAS CHECKED BEFORE AND AFTER OPERATION AT EACH ALTITUDE USING A J[illegible] COMBUSTIBLE GAS INDICATOR, MODEL F, S.N. [illegible]F64.

EXPLOSION - CONTINUED



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1. EXPLOSION - CONTINUED

CONCLUSIONS: SAMPLE 1 MET THE REQUIREMENT OF THE EXPLOSION TEST.

ALBERT G. KLEINKNECHT